Transactions of American Society for Steel Treating

Published Monthly | Cleveland, April, 1923 | Ten Dollars a Year
Vol. III | No. 7
Entered as second-class matter Feb. 7, 1921, at the post-office at Cleveland, Ohio, under the Act of March 3, 1879

SPECIAL FEATURES

Table of Contents, Page 33

4600 Prospect Avenue

TRANSACTIONS

of the

American Society for Steel Treating

Vol. III Cleveland, April, 1923 No. 7

STICKERS OR SLIDERS

ONE of the truisms of life is the saying "A Friend In Need Is A Friend Indeed." Yet, there are few of us who have not had the lamentable experience of finding that those who lay strongest claim to being friends utterly fail to live up to the requirements of friendship when the occasion arises for them to demonstrate the sincerity of their claim.

It is fortunate that there comes in the lives of all men such events as require an alleged friend to demonstrate whether he belongs in the class of "stickers" or "sliders." The ones who slide away from your signal of hope will surprise you and the ones who stick by you in adversity, likewise will surprise you, because the ones from whom you expected so much will show such light regard for the principles of friendship, while those from whom you expected little, prove to be possessors of the greatest adhesive qualities. Yet, we would not have you think you should regard all friends with a feeling of doubt, but we would advise you make as many friends as possible so that if the occasion arises when the test is necessarily carried out, you may have a larger proportion of "stickers" than of "sliders" on your list.

And that point brings up the question "How are we going to make more friends?" We all agree that a correspondence course in friendship is not possible nor would it obtain satisfactory results because it leaves out of consideration the personal touch, the personal element, which is so necessary for a completion and refinement of friendship's possibilities.

There are opportunities and ways by means of which a member of the A. S. S. T. is able to increase his list of friends, and that is by making a greater effort to come in contact with other members of the Society, never losing an opportunity where a few are gathered together to be numbered among those present, by attending National Conventions, Sectional Meetings, and attending regularly your local Chapter Meetings brings you in contact with the best men in the nation and in your city, and the result of this personal contact will indeed be surprising to you.

As an example,—an individual in one of the western chapters became personally acquainted with the men of the chapter through his regular attendance at the Chapter meetings and when he needed an opportunity to show his ability and talent to another firm he had no difficulty in making a satisfactory advancement at a 100 percent increase in salary,—due to the acquaintanceships he had formed and the knowledge of his ability that had been gathered by those with whom he associated.

Another instance in which personal contact and the formation of friendships proved of great value was that of an executive who had become connected with a firm in unfortunate financial difficulties and it was necessary

for them to release him. He had been a regular attendant at meetings and consequently had built up quite an acquaintanceship When some of his friends found out that he was soon to be at liberty they immediately interested themselves in his behalf and within a period of one week he had been selected as works manager of a large western manufacturing firm at a salary of $7,000.00 a year, when previously he had been drawing but $3,500.00.

These are just instances of the value of friendships formed by attending local meetings and they are only indicative of the friendships that one is able to form by attending Sectional and National Meetings. Personal acquaintanceships and friends offer wonderful opportunities to all and if you do not embrace these opportunities as they are offered, you need have no one else to blame but yourself if when the time comes your friends prove not to be "stickers" but "sliders."

SLOGAN

H. ADDINGTON BRUCE, in the Associated Newspapers, writes interestingly and entertainingly on the subject, "Do It Better."

Of all slogans, the young man beginning in business will do well to make it his own, as none is of more importance to him than "Do It Better."

And how often it happens that a man having noticeably progressed through steadfast devotion to the principle summed up in a slogan finally reaches a point where he thinks he may safely spare himself the effort adhesion to it involves. He has arrived he tells himself and now can take things easy. But, he discovers, sooner or later, that to take things easy means to lose ground in a business sense because there are always speedy workers with whom the slogan "Do It Better," has an irresistible appeal.

This is the cause and explanation of many an unexpected collapse of industrial and commercial firms thought to be securely entrenched in the business world. It is the explanation too of frequent demotions of executives. One has only to use one's eyes to perceive that, to many men, the idea of "take it easy" has a stronger appeal than "Do It Better." Their thoughts and efforts are concentrated on almost anything except work improvement.

Naturally they are hopelessly handicapped in competition. They are out-distanced by men perhaps conspicuously their inferiors in point of inborn talent, but imbued with the "Do It Better "idea.

THE ART OF SELLING

IN AN address delivered by Dr. Frank Crane at the New York Life Insurance convention, at White Sulphur Springs, he brought out very forcibly those points which in his mind were paramount to the success of a salesman. As we are all salesmen, selling ourselves to our friends, colleagues, etc., some of Mr. Crane's thoughts will undoubtedly prove of value to our readers as well as to ourselves.

In laying down those points which he considers prerequisites we feel that he has struck the keynotes of the situation. His points are:

1. *Be Agreeable.*—If your voice is disagreeable and your manner of speech indistinct, see specialists. Don't get mad. I like you to be sunny, but I don't want you to get freckles.

2. *Know Your Goods.*—And when you tell me anything, talk plainly. Most salesmen lack imagination. They cannot conceive the extent of my ignorance.

3. *Don't Argue.*—When you argue with a man, you are trying to push

him. He may be weak and pretend to be convinced. Overnight he will change.

4. *Make It Plain.*—Get a grasp on the fellow you are talking with. Do not get out that little book that will only puzzle him. Answer his questions without looking at your books, charts, tables.

5. *Tell the Truth.*—By the law of average, honesty is the best policy and gives the greatest profits. If you are working for a concern where you cannot tell the truth, quit and go elsewhere.

6. *Remember Names and Faces.*—Don't call me Green when my name is Crane. I am sensitive about my name. Don't call me Mr. if my title is Doctor.

7. *Don't Be Egotistical.*—I am. You must not be. Don't show off. You came to sell me something, not to make a good personal impression. Magnify my ego, not yours.

8. *Think Success.*—Radiate prosperity. Do not mention calamities, dirges, funerals. Be a little Pollyanna.

9. *Be Human.*—If the company merely wanted to disseminate information, they would use a catalogue, not you.

ENGINEERS, SCIENTISTS AND EDITORS PLAN TO STANDARDIZE SYMBOLS AND ABBREVIATIONS

A RECENT conference held in New York city under the auspices of the American Engineering Standards committee revealed a sentiment among engineers, scientists, government officials, business paper editors and industrial executives, emphatically in favor of the unification of technical and scientific abbreviations and symbols.

It was agreed on all sides that the standardization of abbreviations and symbols would result in inestimable mental economies. The present situation with respect to the use of abbreviations and symbols in engineering, scientific, and other technical fields is comparable to a language which has degenerated into a multiplicity of dialects each of which has to be translated for the users of the others. Abbreviations and symbols constitute an ever growing and important part of the language of engineers, scientists, industrial editors, and other technical men. The use of one symbol or abbreviation for several different terms and the use of several different symbols or abbreviations for one meaning are, however, at present causing a great deal of confusion, misunderstanding, and, often, serious errors.

The conference was called upon requests from the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the Association of Edison Illuminating Companies, to consider abbreviations and symbols, but after some discussion of the subject it was thought desirable to include as a part of the project, the graphical symbols which are used in engineering drawings, diagrams, and the like, for representing instruments and apparatus and components of them.

It was agreed that the co-operation of foreign standardizing bodies should be sought, in the development of the work. The importance of international uniformity in symbols is great on account of the international character of much engineering and scientific work, and the importance of reference books and periodicals in foreign languages.

The work will go forward under a committee organization developed in accordance with the rules and procedure of the American Engineering Standards committee.

SPRING SECTIONAL MEETING

THE board of directors of the American Society for Steel Treating have accepted the Lehigh Valley chapter's invitation to hold the spring sectional meeting in Bethlehem, Pa. The dates decided upon are Thursday and Friday, June 14 and 15, 1923.

The City of Bethlehem, in addition to being the center of a large industrial community, is ideally located for this purpose, it being 2½ hours ride from New York on either the Central Railroad of New Jersey or the Lehigh Valley railroad; 2½ hours ride from Harrisburg on the Philadelphia and Reading railroad; 1½ hours ride from Philadelphia on the Philadelphia and Reading railroad. Through trains on the Central Railroad of New Jersey from Scranton to Philadelphia pass through Bethlehem and all through trains on the Lehigh Valley railroad from Buffalo to New York pass through Bethlehem, which gives that city excellent train service, it being very accessible from all directions.

The program offered by the Lehigh Valley chapter members is as follows:

Thursday June 14, 1923

11:00 a. m.	Registration.
12:30 p. m.	Luncheon at Hotel Bethlehem.
2:00 p. m.	Technical session at Hotel Bethlehem.
7:30 p. m.	Dinner and entertainment at Hotel Bethlehem.

Friday June 15, 1923

9:30 a. m.	Inspection trip through Bethlehem plants of the Bethlehem Steel Co.
1:00 p. m.	Luncheon, Lehigh university.
2:30 p. m.	Technical session, Lehigh university.

The Lehigh Valley chapter in addition to providing entertainment for their members, have arranged a program which all the visiting ladies will much appreciate. Their entertainment is scheduled as follows:

Thursday June 14, 1923

11:00 a. m.	Registration, Hotel Bethlehem.
12:30 p. m.	Luncheon with members at Hotel Bethlehem.
2:00 p. m.	Auto trip (probably Delaware water gap).
7:30 p. m.	Dinner and entertainment with members at Hotel Bethlehem.

Friday June 15, 1923

10:00 a. m.	Sight seeing trip through historical places of interest adjacent to hotel.
1:00 p. m.	Luncheon with members at Lehigh university.
2:30 p. m.	Card party at Lehigh university in same building in which meeting is held.

The larger industrial institutions in this community which are represented and co-operate with the American Society for Steel Treating are, Bethlehem Steel Co., Bethlehem, Pa.; Bethlehem Foundry & Machine Co., Bethlehem, Pa.; Ingersoll-Rand Co., Phillipsburg, N. J., and Easton, Pa.; International Motor Co., Allentown, Pa., and Wm. Wharton Jr. Co., Easton, Pa.

It is impossible to arrange trips through all of the plants and it was decided that a sight seeing trip through the Bethlehem plant of the Bethlehem Steel Co. would be most interesting.

Two large educational institutions are covered by the field of the Lehigh Valley chapter, they being Lafayette college, located at Easton, Pa., and

Lehigh university, at Bethlehem, Pa. Lehigh university, through its president, Dr. C. F. Richards, is co-operating with the American Society for Steel Treating, and has given over the use of its dining hall and recreation building for the meetings, which will be held Friday. Lehigh university is particularly pleasing, especially at this time of the year, being located on the side of the mountain with its numerous buildings and well kept drives and campus.

A large, modern hotel has been opened in Bethlehem within the last year which can accommodate all who wish to attend the meetings. The Hotel Bethlehem is absolutely fireproof and its manager has offered the use of all of its facilities to the American Society for Steel Treating for their June meetings. The Lehigh Valley chapter feel that it would be better to have hotel reservations made through them rather than by direct communication with the Hotel Bethlehem, and it is requested that any one who desires to make reservations, should get in communication with G. C. Lilly, superintendent of the heat treatment department, Bethlehem Steel Co., Bethlehem, Pa., who will handle the matter.

The following men have given their consent to present papers at this meeting:

Dr. F. C. Langenberg, Watertown Arsenal.
V. Hybinette, British-American Nickel Co.
F. R. Palmer, Carpenter Steel Co.
B. F. Shepherd, Ingersoll-Rand Co.
R. H. Christ, Bethlehem Steel Co.

The subjects of these papers will be announced at a later date.

The entertainment committee, which consists of the following men;

W. R. Shimer, Chairman,
H. S. Brainerd,
A. Hummel,
F. P. Martin,
W. H. Laury,

have planned a good time for all and have guaranteed that all the members and their ladies will feel sorry that the sectional meeting was not a week long in place of only two days, and feel that in addition to the technical side that the social side will be well taken care of.

The meeting and inspection committee, of which Mr. Lilly is chairman, consists of the following members;

R. M. Bird,
F. V. Larkin,
R. H. Christ,
E. B. Shimer,
B. H. DeLong,

who have had the co-operation of the Lehigh university and are under obligation to the Bethlehem Steel Co. for their kindness in allowing an inspection trip which is scheduled for Friday morning, through the Bethlehem plant of that corporation.

It is hoped that all those who can possibly attend will be on hand in Bethlehem on June 14 and 15, as the Lehigh Valley chapter is composed of live wires and if their past is any criterion, the sectional meeting is sure to be a success in every way.

THE USE OF VARIOUS KINDS OF LIGHT IN METALLOGRAPHY

By Robert G. Guthrie

Abstract

This paper deals with a short discussion of the physics of light and a few of the important laws which govern the action and behavior of light and light waves.

After briefly discussing light the author turns to a discussion of the optics and mechanics of the metallurgical microscope as it is manufactured today. He discusses the various types of photographic plates which are available for photomicrographic work, indicating that the panchromatic plate gives the highest degree of satisfaction in making photomicrographs of opaque objects.

The use of ray filters and monochromatic light by the dispersion of white light into the different colors of the visible spectrum are reviewed. The use of polarized light in the photomicrography of opaque objects is discussed at some length and photomicrographs made by this method are included with this paper. Specimens of photomicrographs showing the magnifying power of the usual type metallographic camera are displayed. A photograph at 11,000 *diameters magnification is included.*

Introduction

LIGHT is an agent, the action of which on the retina of the eye, excites the sensation known as vision. Various hypotheses have been advanced to explain the origin and transmission of light, the most important being the emission of corpuscular theory, and the undulatory or wave theory. The emission theory assumes that luminous bodies emit in all directions, some substance, the molecules of which are propagated in lines at enormous velocity. This theory has long since been discarded, and the one accepted is the wave, or undulatory theory, which assumes that all bodies and all space is filled with an extremely subtle elastic medium called *ether*.

The luminosity of a body is due to an infinitely rapid motion (possibly vibratory) of its atoms, which, when communicated to the ether, are propagated in every direction as spherical waves. These light waves, however, do not vibrate in a plane parallel to the direction of propagation, but in a plane at right angles to it. An example that may illustrate this point is that of a water wave, which, although apparently moving in a given direction, vibrates in a plane at right angles to its direction of propagation. Another example is that of a caterpillar moving along in a straight line. In every homogeneous medium, the propogation of light is rectilinear. Light changes its direction when it meets an object which it cannot penetrate, or, when passing under certain conditions from a medium of a given density to one of a greater or less density.

Reflection and Refraction Phenomena

These phenomena are manifest by what is known as reflection and re-

A paper presented before the winter sectional meeting held in Chicago Feb. 8-9, 1923. The author, Robert G. Guthrie, is metallurgist with the Peoples Gas Light and Coke Co., Chicago.

fraction. An example of reflection which is well known, is the change of direction of the propagation of a pencil or beam of light by a mirror. There are two laws which govern the reflection of light, and radiant heat as well:

1. The angle of reflection is equal to the angle of incidence.
2. The incident and reflected ray are both in the same plane and this plane is perpendicular to the reflecting surface. The intensity of reflected light must always be less than the incident light due to the absorption of a part of the incident light by the reflecting body.

The phenomenon of refraction is seen every day by all of us, as that peculiar form of distorted vision that we see when looking at an object through a glass filled with water, or through a bubble or imperfection in a window pane. When a beam of light passes obliquely from one medium to another of different density, it suffers refraction. All of this beam, however, does not enter the second medium, but a portion of it is reflected; also, all of the beam which enters the second medium is not refracted, but a part is absorbed and appears as heat. The portion that is reflected is subject to definite laws. In isotropic bodies, such as air, liquids, and ordinary glass the ray is singly refracted, and two laws known as the Descartes laws for single refraction are:

1. Whatever the obliquity of the incident ray, the ratio which the sine of the incident angle bears to the sine of the refraction angle, is constant for the same two media, and the same colored light, but varies with different media.
2. The incident and refracted rays are in the same plane which is perpendicular to the surface separating the two media.

Refractive Index

The index of refraction or refractive index of the second medium with respect to the first, is the ratio between the sines of the incident and refracted angles. This may be expressed as follows:

Let A = the refractive index
B = the angle of incidence
C = the angle of refraction
Then, Sin B = A Sin C

The refractive index varies with the media, as from air to glass it is 3/2 and from air to water it is 4/3; in other words, the refractive index of water is 1.333 and for glass 1.500. If the refractive index of a substance is given without qualification, such as just the figure 1.333 for water, it is understood that the light is passing from air into the substance. If, however, the light is passing from water to air, it follows the same course but in a contrary direction, with the consequent result that the index of refraction is reversed and the figure 4/3 from air to water becomes 3/4 from water to air.

It is apparent that the index of refraction varies with different media and the following figures for different substances will make this clear. Remember, however, that the light is passing from the air into these media. Ethyl ether 1.36, ethyl alcohol 1.37, turpentine 1.47, crown glass 1.53, flint glass 1.63, diamond 2.75. A point which is now obvious is that optical density is not the same as ordinary density, inasmuch as the index of refraction of

ethyl ether, ethyl alcohol, turpentine, etc., is larger than the index of refraction for water, but they are all lighter than water. This optical density gives rise to another law as follows:

> Light passing from a less dense medium to one of greater density obliquely to the surface separating the two, is bent toward the perpendicular to that surface, and conversely, in passing from a more dense medium to a less dense medium, it is bent away from the perpendicular.

The question may now arise as to why a beam oblique to a surface is bent or refracted, whereas one perpendicular to that surface is not, and the explanation is found in the velocity of light. The velocity of light is approximately 3 x 10^{10} centimeters per second, or 186,000 miles per second. When a beam of light passes from one medium to another, the velocity in the first medium is to that in the second inversely as the refractive indices of the media, which means that the velocity of light in water is three-fourths that of its velocity in air, and the velocity of light in the glass, having a refractive index of 1.5 is 2/3 of its velocity in air.

A beam of light passing from air to water perpendicular to the surface of water, is not refracted, but is equally retarded along its entire length for the reason of the fact that light travels only three-fourths as fast in water. Also the angle of incidence of the beam is 90 degrees, but if the beam makes an angle less than 90 degrees with the surface of the water, the wave front which is always perpendicular to the direction of the propagation must strike the surface on one side before it strikes on the corresponding point directly opposite. As an example, incline a water glass slightly with the top of a table, and it will be seen that the table and the glass touch only on the edge. As the velocity of the entire wave front is constant, the point first striking the medium which retards its velocity by one-fourth will have traveled into the water before the point which was opposite in air has reached the surface, with the result that there will be a swinging of the entire beam toward the common perpendicular, and inasmuch as the wave front is always perpendicular to the beam, there will be a change of direction.

The numerical value of the refractive index is always the ratio of the velocity of light in the first medium to its velocity in the second, and when light passes into a medium of greater density, the index is greater than one and the ray is bent toward the perpendicular and conversely when light passes into a medium of less density, the index is less than one and the beam is bent away from the perpendicular. A beam of light, therefore, can always pass from a less dense medium to one of greater density as it is bent toward the perpendicular, but a ray cannot always pass from a dense into a less dense medium for the reason that if the ray is bent away from the perpendicular more than 90 degrees it would not emerge. A beam of light cannot pass from water into air if it makes a greater angle with the perpendicular than 48 degrees 35 minutes. This is known as the critical angle and beams that make greater incident angles than the critical angle are *totally reflected.*

This principle of refraction is responsible for the various effects produced by lenses. If a piece of glass, say 3 inches in diameter and 1 inch thick is placed perpendicular to a beam of light, the light in passing will suffer no refraction, but if one of the surfaces is curved outward toward the beam, the effect will be analogous to the oblique beam striking the plane surface of the water just mentioned, but in this case, the surface is oblique

to the wave front. The effect produced will be to refract or bend the wave front toward the common perpendicular.

The foregoing is given merely to explain a few terms such as reflection, refraction, refractive indices, wave front, etc., and to give a brief account of the phenomena which make lenses possible, and which in turn, make possible our present day microscopes, field glasses, telescopes, cameras, motion picture and stereopticon projectors, and ordinary eye-glasses.

The Metallurgical Microscope

The metallurgical microscope is dependent entirely upon light for its existence as a useful mechanism. The lens systems are complex, and as you have seen by the short description just given, the nature of light and its application bids fair to be the most complex element entering into its use, however, thanks to the optician and physicist, the troublesome details of the lens combinations have been attended to. Their proper spacing, mounting and positions have been determined when the instruments were made and with proper care and attention to illumination and photographic materials and equipment, proper and satisfactory photographs may be obtained. It is the writer's opinion that any specimen worth photographing is worthy of the best photomicrograph that can be taken of it. If this rule were followed we should have fewer poor and unintelligible photomicrographs.

The illustrations in this paper are not in any sense of the word examples of perfect photomicrographs, but they represent three points which are brought out in this discussion. These points are as follows:

1. Kind of light used.
2. Polarized light, plain polarized and analyzed.
3. Magnification, normal and extreme.

By the kind of light used is meant white light, which is a compilation of all the colors known to us in the visible spectrum. Monochromatic light is a light of a definite wave length and is consequently of definite color, or semimonochromatic light, is a light of a narrow range of wave lengths, and consequently apparently one color. The nature of white light is such that it is composed of various colored lights of wave lengths within the visible spectrum, between 4000 and 7000 Angstrom units. A wave of the darkest violet that can be seen will be about 4000 Angstrom units in length. The Angstrom unit is one ten-millionth of a millimeter, and a wave of the darkest red that can be seen is about 7000 Angstrom units. We can make photographs with any of the various wave lengths within the visible spectrum, as well as some of the shorter wave lengths above 4000 Angstrom units, which affect the photographic plate, but which are not visible to the eye. Examples of these are the ultra-violet and violet, and are sometimes referred to as the chemical rays.

Photographic Plates

The photographic plates such as are used for photomicrography may be either the ordinary gelatine plates, the orthochromatic, the isochromatic or the panchromatic. In the matter of the selection of plates it is well to remember that the ordinary gelatine plates are sensitive toward the red end of the spectrum as far as the green, whereas the orthochromatic plates are sensitive to the orange and panchromatic plates are sensitive to the infra red. This latter class of plate in the writer's estimation is the ideal plate

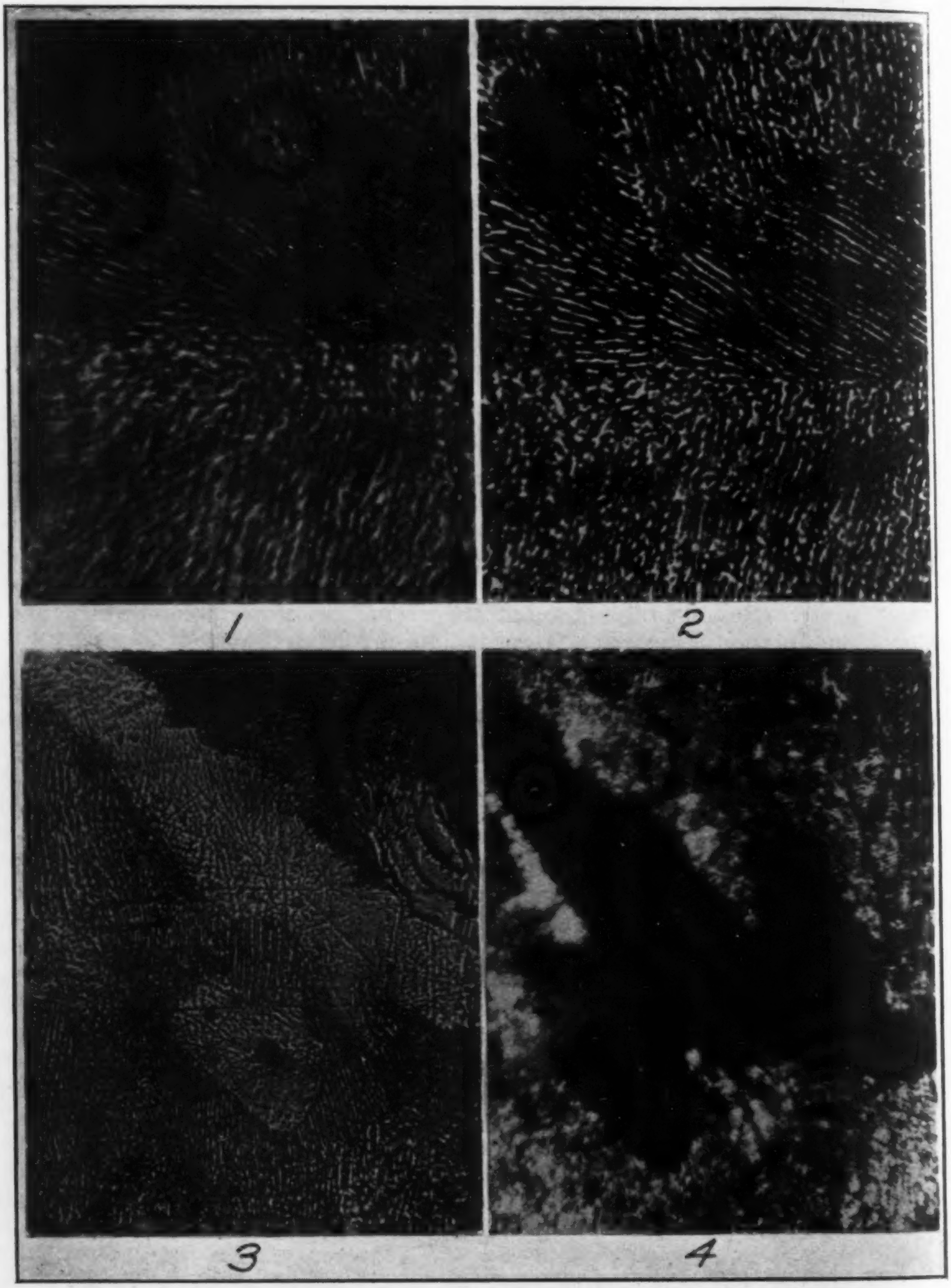


Fig. 1—Photomicrograph Of Lamellar Pearlite Taken Without The Use Of A Ray Filter. x 2000. It Will Be Seen That The Photograph Lacks Contrast And Has A Blurred Effect Due To The Use of White Light At High Magnification. Fig. 2—Same Section As Fig. 1 With The Same Equipment But In This Case A Light With A Spectral Transmission Of 4600-6000 A. u. Was Used. Fig. 3—Photomicrograph Made By Using The Arrangement Of Polarizer And Analyzer As Shown In Fig. 7. Fig. 4—Photomicrograph Made By Rotating The Analyzer Through 90 Degrees, Thus Reversing The Colors Of The Constituents As When Oblique Light Is Used. These Photomicrographs Were Taken At x 1000.

to be used where the best results are desired. These plates must be handled and developed in a room totally dark, or by the light of a special lamp recommended by the manufacturer of the plates.

Ray Filters

Another important point that must be taken into account if the best results are to be secured is that it is necessary to have a set of ray filters furnished or recommended by the manufacturer of the plates. These ray filters consist of gelatine films stained by various dyes cemented between glass plates, and although these filters do not produce perfectly monochromatic light, they produce light of various dominant wave lengths, with the result that the microscopist has a larger choice of wave lengths and colors from which to work. Certain combinations of these filters give practically monochromatic light. There is, however, another way to obtain monochromatic light which is no doubt superior to all others, and that is by separating a beam of white light into all its different colors by the use of suitable prisms. It is necessary that each band of color be wide enough to be used for illumination. However, for all practical purposes of photomicroscopy, panchromatic plates with a set of suitable filters will give excellent results. Filters of colored glass as supplied with some instruments are generally suitable for ordinary plates but not at all suitable for the panchromatics.

The reasons for the use of light of different colors, or different wave lengths, are several, among which is to obtain greater contrast between the various constituents. It is ordinarily not necessary to employ any but white light with magnifications below 100 diameters, but above this point they become necessary, and at very high magnifications of 2000, 3000, 4000 diameters, and upwards, their use becomes imperative. An example of this is shown in Figs. 1 and 2. Fig. 1 is a photomicrograph of lamellar pearlite taken at 2000 diameters without the use of a filter, and it will be seen that the photograph not only lacks in contrast necessary to bring out the detail, but gives the blurred effect which is another consequence of using white light at high magnifications. Compare Fig. 1 with Fig. 2, which is the same section photographed with the same equipment but in this instance a light was used having a spectral transmission of 4600 to 6000 Angstrom units and, therefore, of a green color. Figs. 5 to 11, dealing with increased magnification, were all taken of lamellar pearlite, with light of the same wave length as was used in the case of Fig. 2.

Resolving Power of Objectives

The relation of the wave length of light to the resolving power of the objectives is a most important issue. The resolving power of an objective is frequently referred to in lines per inch, that is, an objective is frequently spoken of as being capable of resolving 25,000 lines per inch. The distance between two lines which can just be distinguished (or resolved) by the objective, is equal to one-half of the wave length of light, divided by the numerical aperture of the objective. The formula expressing this is:

$$D = \frac{1}{2}\,\frac{Wl}{N\,A}$$

Where D = the distance
Wl = the wave length of light
N. A. = the numerical aperture

It will immediately be seen that the shorter the wave length of light, the

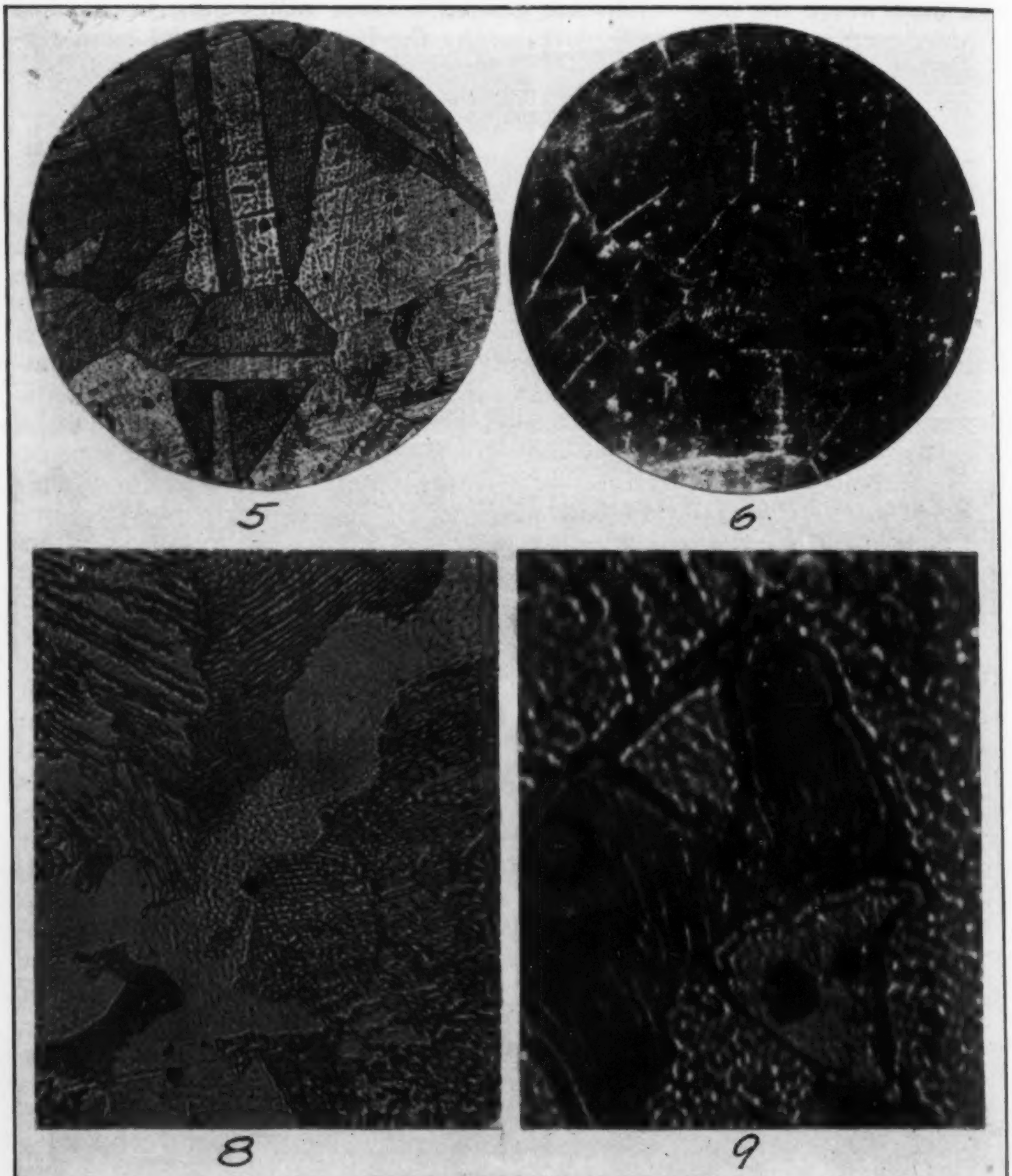


Fig. 5—Photomicrograph Made Using The Arrangement Of Polarizer And Analyzer As Shown In Fig. 7. Fig. 6—Photomicrograph of Same Section When The Analyzer Is Rotated 90 Degrees. It Will Be Noted That The Colors Are Apparently Reversed As When Oblique Light Is Used. These Photomicrographs Are Magnified x 300. Fig. 8—Lamellar Pearlite Photographed At A Magnification Of x 1200. Fig. 9—Low Carbon Steel Showing Ferrite, Ferrite Grain Boundies, And A Central Area of Lamellar Pearlite. x 2300. These Last Two Pictures Were Taken With Vertical Illumination.

greater the resolving power. Very interesting and useful figures may be compiled from the above formula. For example, the highest numerical aperture obtainable is about 1.40, and using a wave length of light of 6000 Angstrom units the lines resolved per lineal inch will be, roughly, 125,000, whereas with a wave length of 4000 Angstrom units the lines resolved per lineal inch would be nearer 200,000. This, however, is not possible as the volume and intensity of light would be insufficient in the first place, and in the sec-

ond place, it would not be visible enough to focus. A point to remember in connection with the use of filters is that the final focusing must be done with the filter in place, as poor results will be obtained if the focusing is done with white light and the filter placed in the beam later.

Polarized Light

The attempt to use polarized light for the examination of opaque objects was made in the hope that it might prove of value in some classes of work. The writer admits the attempt has not been very complete as yet but will explain what is meant by polarized light.

In the first part of this paper, we spoke of refraction as single refraction. Now, if a beam of light is passed through a crystal of Iceland spar (a transparent calcite) or a tourmaline crystal, in the proper manner, the ray breaks up into two rays of equal intensity; one known as the ordinary ray, and the other, the extraordinary ray. Practically speaking, in the polarizers

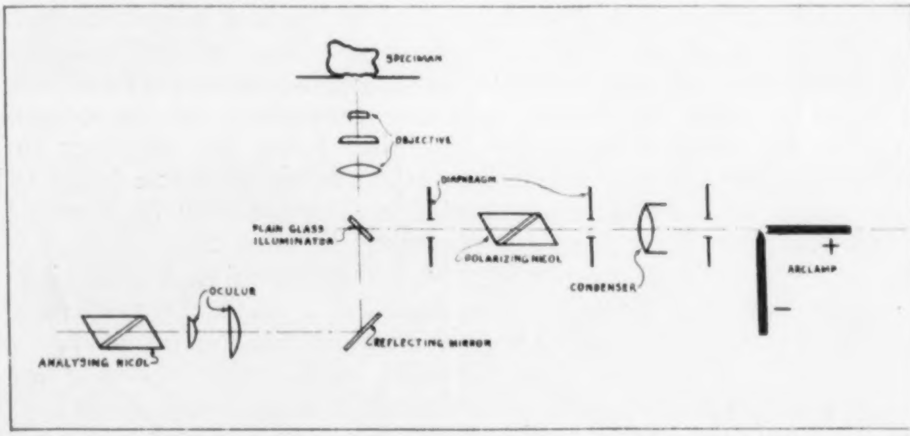


Fig. 7—Diagrammatic Sketch Of The Usual Inverted Type Metallographic Microscope With The Polarizer And Analyzer In Place.

used, the ordinary ray is refracted through the sides of the crystal and absorbed while the extraordinary ray passes on through and is said to be a ray of plain polarized light. It is an essential of such a polarizer that another crystal is used to analyze the plain polarized beam.

Before going further, it might be well to explain more fully what is meant by a polarized beam and we will use an illustration given in an elementary textbook by Henderson and Woodhull.

By fastening a cord at one end, and holding the other in the hand, the cord is made to ripple in all possible planes, it will very crudely represent an incident ray of light. If this cord in place of being fastened at one end is passed through two gratings whose openings are rectangular in shape, and these gratings are placed some distance apart, a fair representation of a polarizer and analyzer is seen. When the direction of both these slits is placed vertical, and the cord made to ripple up and down, vibrations pass along its full length. If both gratings are revolved through 90 degrees and the cord made to ripple horizontally, the cord will also vibrate throughout its length, but if the grating furtherest from the hand is turned through 90 degrees to the vertical position and the other left horizontal and the cord rippled horizontally, it will be seen that the end furthest away from the

hand, transmits no vibrations, therefore, remaining stationary. Something similar to this appears to happen to a beam of light passing through a crystal of Iceland spar.

A very convenient and logical way to imagine natural light or incident light as opposed to polarized light is to assume that the ray of incident light is plain polarized and subject to sudden and irregular changes. If these changes take place very slowly the two rays, the ordinary and extraordinary, would not be of equal intensity, but if these changes take place more rapidly than the eye can follow them, we would have what is apparently two images of equal intensity at any given time interval. Assuming that the eye can detect alternations at time intervals of one-fiftieth of a second or faster and these changes occur within such a time factor or time cycle, then we would see what we might term alternating or circular light by a varying intensity of the ordinary and extraordinary ray. The question will now naturally arise as to why it is necessary to use a calcite rhombohedron such as a crystal of Iceland spar.

If the incident beam is presumed to be in reality a plain polarized beam, the answer according to the present line of reasoning would be that the ordinary ray is made to refract in such a way as to be absorbed before it passes out of the end of the polarizer and in so separating these rays and eliminating one we have in effect eliminated only one time-phase of the original beam which allows the extraordinary ray emerging from the polarizer to vibrate in one direction for any given time interval and this direction being only relative to our purely imperialistic standard for direction may be changed by revolving the polarizer through any angle about its own axis.

The great obstacle in preventing the human mind from viewing natural phenomena as they really are, is not the fact that the eye cannot change quickly enough to follow the change in time-phase or alternation of a beam of light, if such is the case, but rather that the mind itself cannot conceive very much that does not lie close to its own set values of things which we call standards. These standards are probably not even close approximations to absolute conditions of various phenomena, but are only relative. It is a fair question then to ask what they are relative to, and the logical answer seems to be that they are more often relative to a given and somewhat limited set of present mental conceptions than to any actual true and absolute values of any given phenomena for which a given value or standard is set by a human mind.

Arrangement of Apparatus for Making Photomicrographs With Polarized Light

Fig. 7 shows a diagrammatic sketch of the usual inverted type metallurgical microscopic camera with the polarizer and analyzer in place. When these are so arranged that their axes are parallel, the ray of light passes through, giving apparently the same image as when a beam of incident light is used.

Figs. 3 and 5 show photomicrographs made using this arrangement of polarizer and analyzer. By rotating the analyzer through 90 degrees, the colors are apparently reversed, as when oblique light is used. Figs. 4 and 6 show photomicrographs of sections corresponding to Figs. 3 and 5 respectively when the analyzer is rotated 90 degrees. These two photomicrographs were taken at 1000 and 300 diameters magnification, respectively. With an oil immersion objective it would be impossible to get a photomicrograph at 1000 diameters magnification with oblique illumination by the present ordinary methods.

Theoretically, if the two crystals are parallel, the beam of polarized light

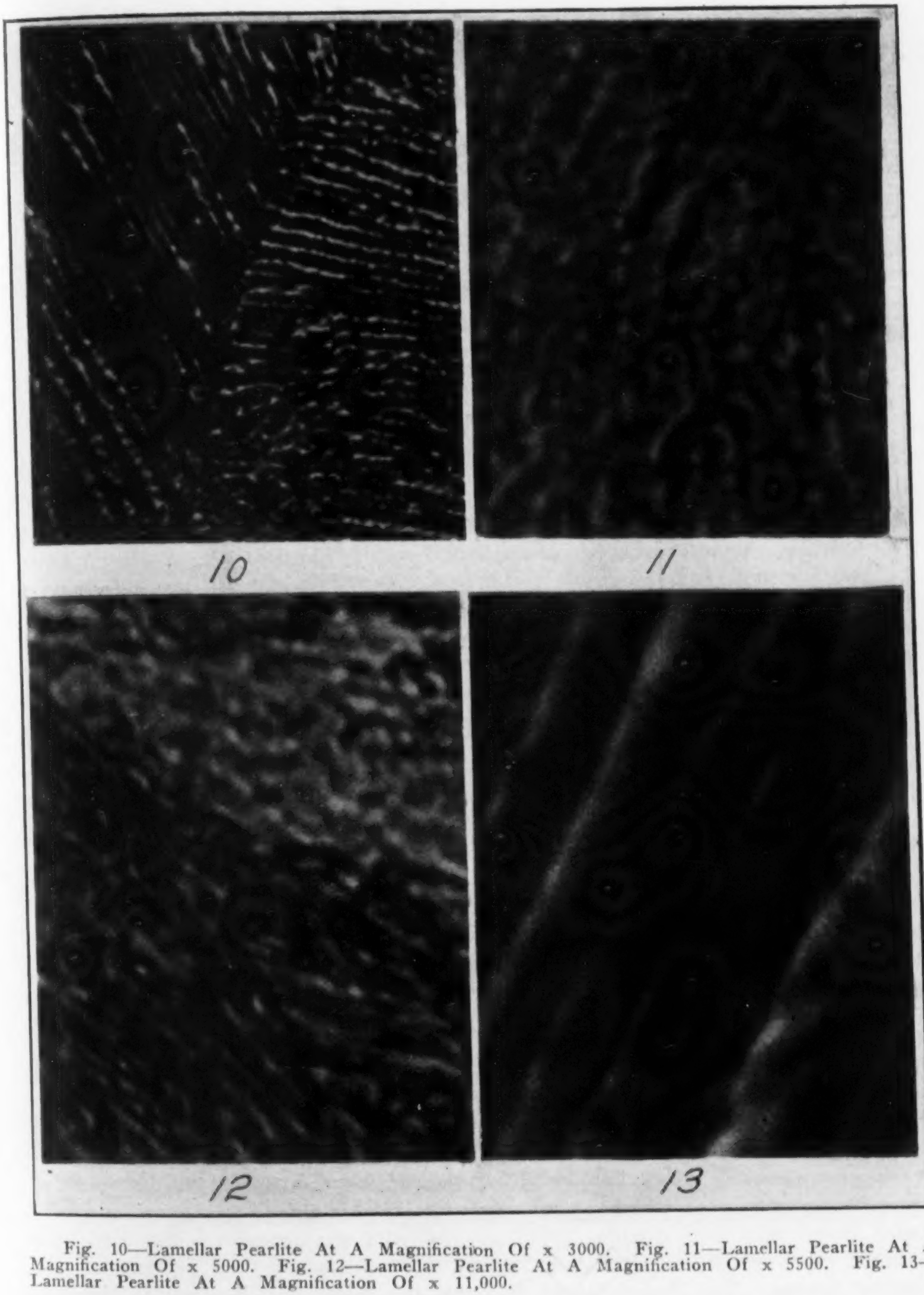


Fig. 10—Lamellar Pearlite At A Magnification Of x 3000. Fig. 11—Lamellar Pearlite At A Magnification Of x 5000. Fig. 12—Lamellar Pearlite At A Magnification Of x 5500. Fig. 13—Lamellar Pearlite At A Magnification Of x 11,000.

passes through to the eye unchanged, but when the analyzer is rotated through 90 degrees, the luminosity of the field decreases until at just 90 degrees it is entirely dark; no light being transmitted by the analyzer. This condition occurs from destructive interference.

(Continued on Page 757)

SELECTION OF ELECTRIC FURNACES FOR STEEL TREATING

By C. L. Ipsen

Abstract

This paper points out the fact that the electric heat treating resistor-type furnaces are coming into more universal industrial use. A few years ago the electric furnace was considered a laboratory devise and not applicable to commercial use due to the high cost of electrical current and frequent breakdowns.

With improved design and an increased cost of gaseous, liquid and solid fuels the electric furnace is coming into use more and more. Its automatic control and its favorable atmospheric conditions surrounding the furnace and its cleanliness makes it an apparatus suitable for installation in locations in a shop other than the heat treating department. It can be placed in the line of production thus eliminating much handling of material.

A FEW years ago the electric furnace was generally considered as nothing more than a laboratory device, used in the laboratory because of the accurate results obtainable but shunned as a production furnace because of its unreliability. Furthermore, its use in production was not seriously considered because it was assumed that the high cost of the heat unit derived from electric energy would make the cost of heat treating prohibitive.

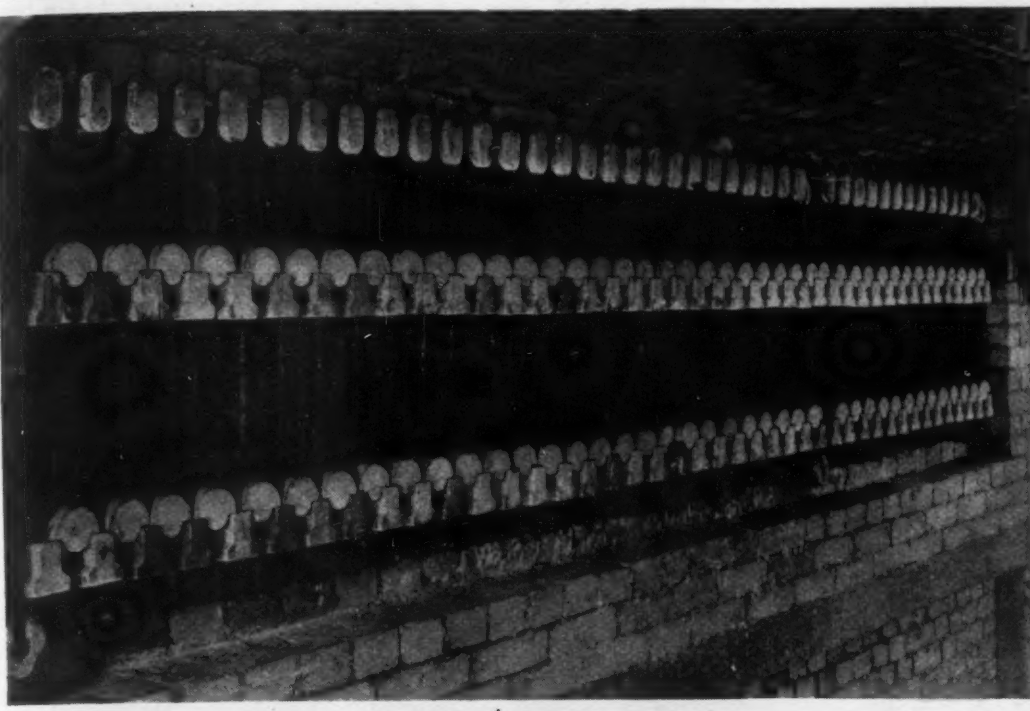
Design of Electric Furnaces Much Improved

By degrees electric furnace designs were improved and the troublesome features of the laboratory furnace construction were eliminated. Thus, for the past two or three years electric furnaces have been available that are fully capable of withstanding the rigors of large scale production rather better than their fuel fired brethren.

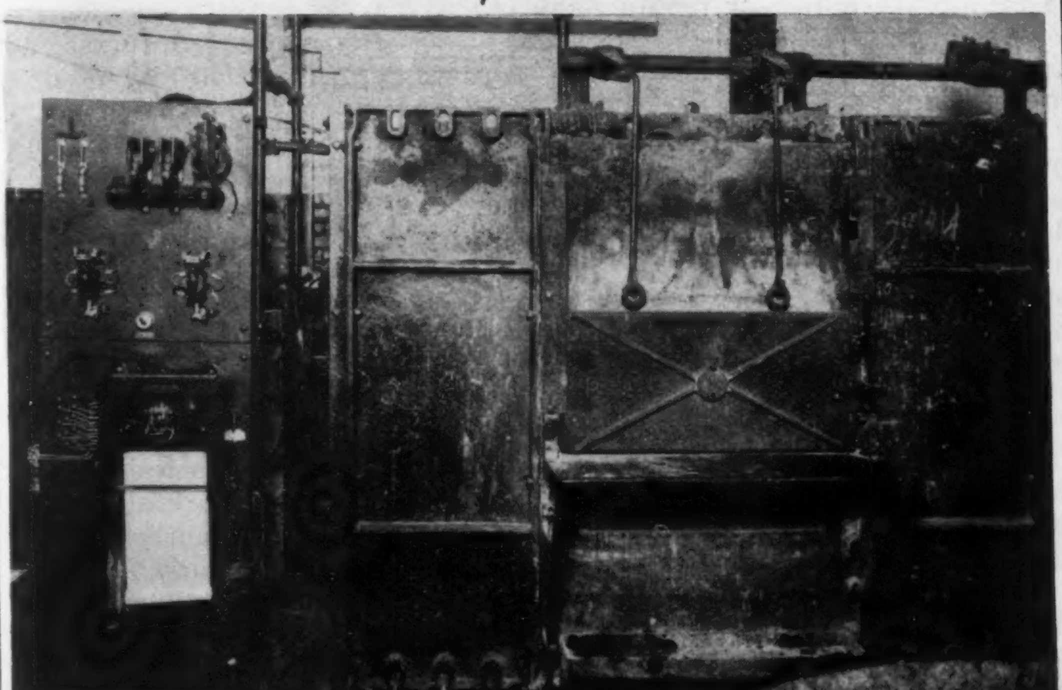
Perfection of design, however, answered only one of the objections. It still remained to prove or disprove the theory of high operating costs. The actual operation of only a few furnaces was required to show the fallacy of putting too much emphasis on British thermal units. There proved to be other considerations such as improved working conditions, reduced labor, improved quality of product, lower rejections, and lowered cost of subsequent operations that far outweighed the difference in British thermal unit cost between fuel and electricity in heat treating. So pronounced was the success of these first production furnaces that in an extremely short time the electric furnace has established itself as the standard where high-grade steel treating is required.

The electric furnace is now available in almost every form to suit the varied requirements of the steel treating field. The development of the many types has been greatly aided by the fact that most of the fuel-fired furnace types readily lent themselves to electrification. One feature of the electric furnace that distinguishes it from the fuel-fired furnace is that the restriction on its proper location in the line of production has been removed. It is not necessary with the electric furnace to restrict it to a furnace room

A paper presented before the Detroit convention of the society, October 2-7, 1922. The author, C. L. Ipsen, is designing engineer, industrial heating department, General Electric Co., Schenectady, N. Y.



1



2

Fig. 1—Arrangement of Electric Heating Units on Side Wall of Car Type Furnace. Fig. 2—Electric Resistance Furnace with Panel and Instrument for Automatic Temperature Control.

apart from the manufacturing space on account of its noise, obnoxious fumes and intense waste heat, but it can be so located as best to fulfill its mission as a link in the manufacturing chain. Thus, what was once classified as one of the intangible advantages of the electric furnace, its absence of noise.

fumes and waste heat have become one of its chief advantages from the standpoint of actual savings. This feature has opened up for it a large field for relatively small electric furnaces of the automatic or semiautomatic type placed in the machine shop in the path of production.

Good Atmospheric Conditions Surrounding Electric Furnaces

Comparative tests made in a large plant illustrate this feature. On two furnaces of similar construction—one electric and one fuel-fired—tests were taken simultaneously of the atmospheric conditions surrounding the furnaces, as follows:

Electric Furnace—	
Temperature	79 degrees Fahr.
CO_2	4 per cent
Humidity	60 per cent
Fuel-Fired Furnace—	
Temperature	121 degrees Fahr.
CO_2	7 per cent
Humidity	23 per cent

It is estimated that a man's vitality after four hours' work in the atmosphere surrounding the fuel furnace would equal that of the man working in the atmosphere surrounding the electric for eight hours. It also shows vividly the reason for restricting the fuel furnace to the furnace room.

The many types of electric furnaces available bring to the mind of the prospective purchaser the question of selection, and it is a question that deserves more careful thought and study than is often given. A furnace not suited to the parts being heat treated or to the shop production may result in serious losses.

Many do not appreciate that a furnace must be designed with as much care as a motor or a machine tool, and in as great variety. It has been assumed too often in the past that a furnace was simply a pile of brick with a hole for a burner. It is not within the province of this paper to enter into a discussion of the many factors that surround the selection of electric furnaces for the great variety of steel treating requirements—each application would be worthy of a paper in itself—but rather to indicate briefly what furnaces have been installed to meet certain specific requirements.

Furnaces Automatically Controlled

The furnaces under discussion are of the direct-heat or open-resistor type. These furnaces are heated by heavy nickel chromium ribbon formed in loops and supported on the interior surface of the furnace in such a manner that the heat is radiated directly to the charge. This construction is clearly illustrated in Fig. 1. The temperature of the furnace is automatically maintained at a constant value by a temperature controlling instrument, which operating through suitable contactors in the main circuit throws the current on and off the resistors. By means of this special temperature control a maximum temperature variation of plus or minus five degrees Fahr. can be maintained.

One requirement met in almost every shop is for a furnace to heat tools and dies. Fig. 2 illustrates one of the first furnaces of direct-heat type, placed in commercial operation for this class of work. The principal output of the furnace is large complicated dies used for making field and armature punchings. This furnace since it was electrified (it was previously a fuel-fired furance) has been in continuous operation for three years without any repair to its heating equipment, nor is there any evidence of its deterioration.

The current is thrown on at 4 a. m. and off at 4 p. m. automatically by means of a time clock. The heat treater using this furnace, recently stated that this furnace has been up to temperature and ready for use every morning without a single exception for three years. This illustrates the dependability and convenience of furnaces of this type.

Fig. 3 shows a furnace designed for a similar purpose but of a more

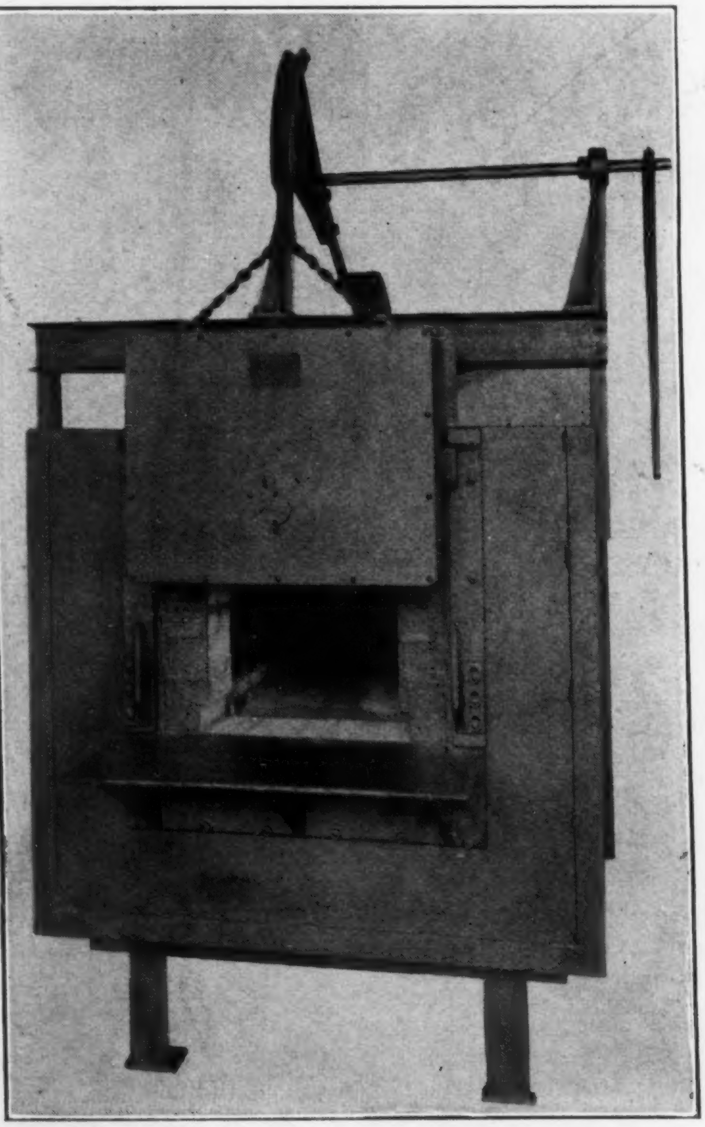


Fig. 3—Box Type Electric Resistance Furnace. Inside Dimensions 18" wide, 36" long and 15" high. 27 KW, 110-220 Volts.

modern type. A hearth of highly refractory metal is used and the resistors are so installed as to reflect a portion of their heat to the bottom of this hearth.

Where it is desired to heat treat parts too large and bulky to be placed in a box type of furnace, the car bottom furnace may be used. Fig. 4 shows a furnace used for annealing sheet steel punchings. A charge of eight to 10 tons is annealed to a temperature of 850 degrees Cent. in 14 hours. The picture shows an annealing cover which was provided to guard against the

possible oxidation of the punchings. After a few runs the use of cover was discontinued, as it was found that the amount of oxidation in the open furnace was so slight as not to be objectionable. This furnace is so designed as to complete its annealing cycle at night, thus obtaining the benefit of low power rate offered by many of the control stations for off-peak power.

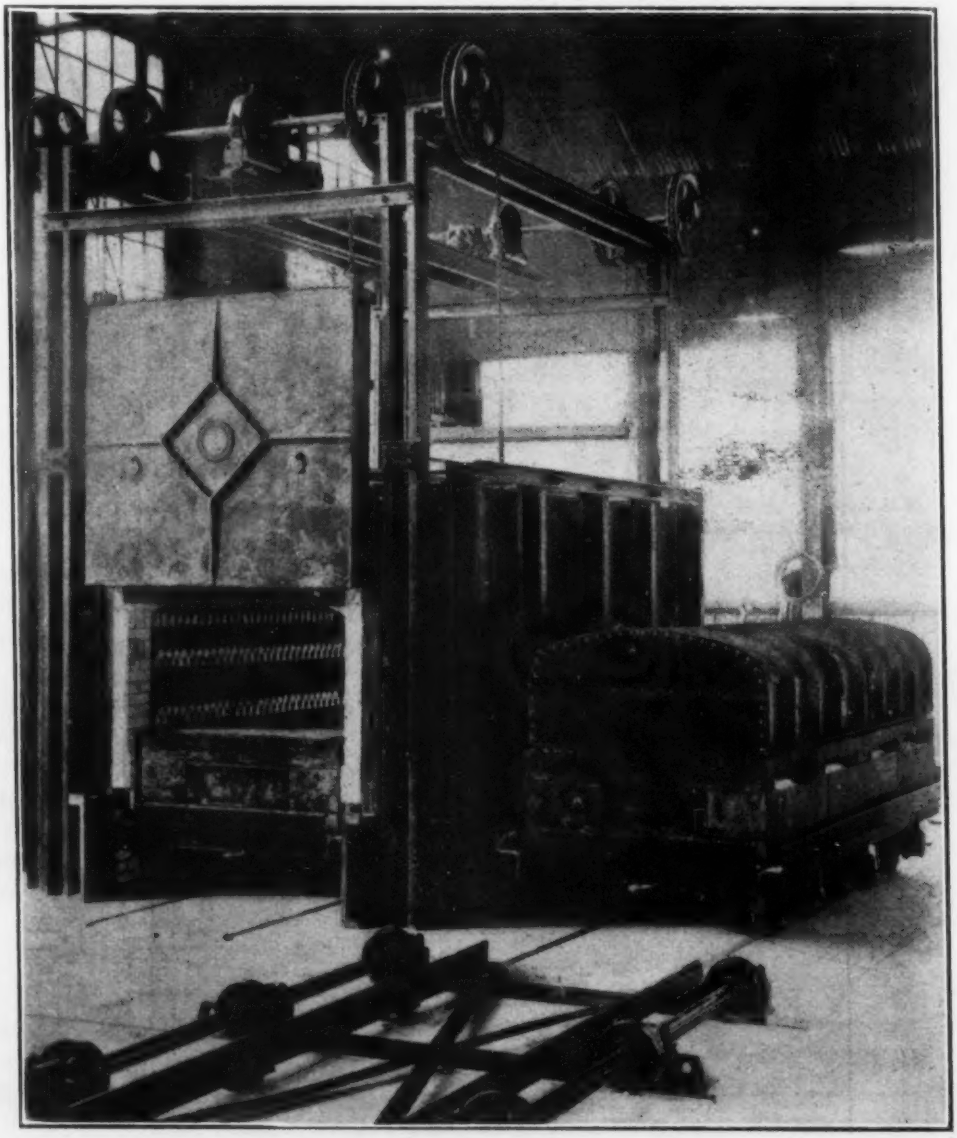
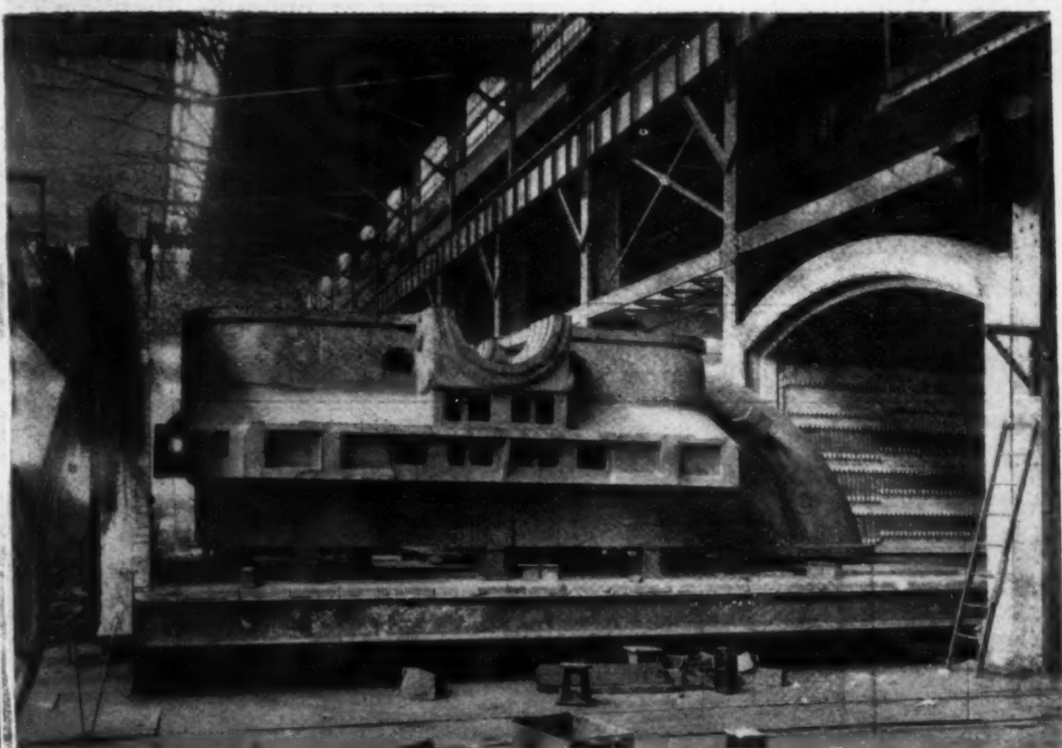


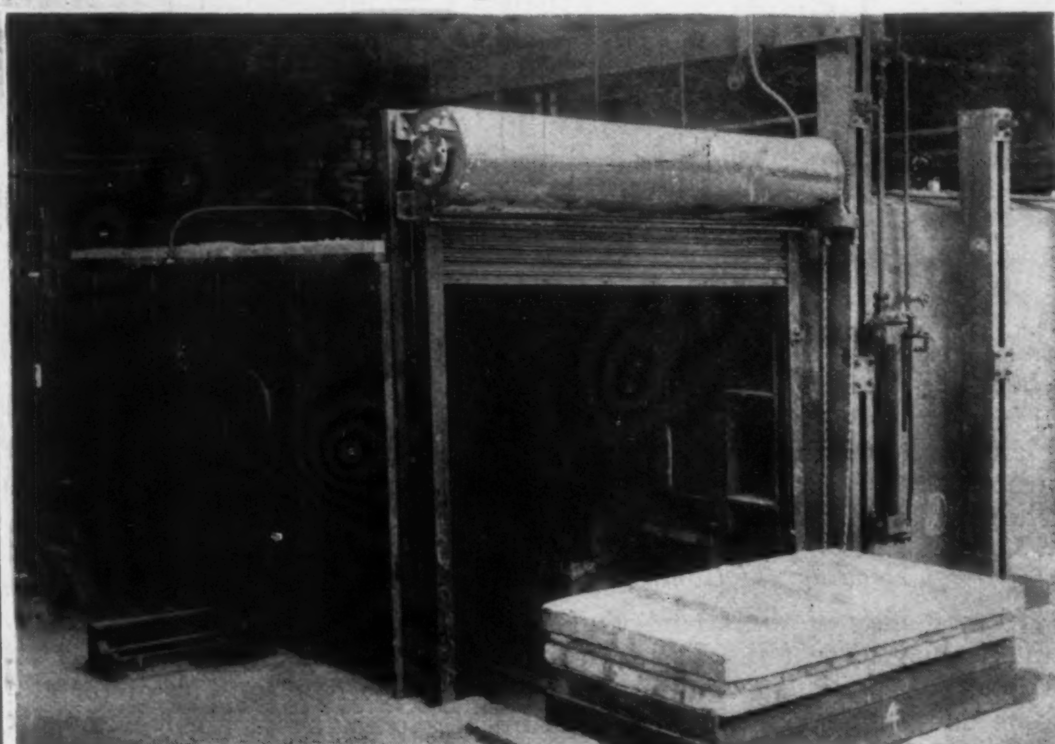
Fig. 4—Car Type Electric Furnace for Annealing Transformer Laminations in Containers.

Fig. 5 shows another car bottom furnace used for annealing or ageing large gray iron castings. A 50-ton charge is shown on the car. It has been found that a low temperature anneal (about 550 degrees Cent.) is sufficient to relieve the strains and give the castings a permanent set. On account of the uniformity of temperature distribution and the close temperature control of the electric furnace, it has been found ideally suited for this work.

A furnace of the compensating type for annealing cast iron is shown in Fig. 6. The furnace is five car lengths long and two wide. The heating chamber is equal in length to one car and is located at the center of the



5



6

Fig. 5—Electric Heat Treating Furnace equipped with Automatic Temperature Control. Dimensions of Heating Chambers 15'-10" wide 27'-7" long and 8'-7" high. Maximum Operating Temperature 1000° Fahr. 620 KW, 550 Volts, 3 Phase. Fig. 6—Car Type Compensating Electrically Heated Annealing Furnace. Heating Chamber 3'-10" wide, 5'-6" long and 3' high. Connected Load 180 KW—Operating Temperature 1450° Fahr.

furnace. With the two trains of cars working in opposite directions, the car emerging from the heating chamber thus gives up its heat to the incoming cars. The castings in this manner derive a large part of their heat from the outgoing charge and reduce materially the current consumption.

A furnace which is well adapted to the heating of a great variety of parts is shown in section in Fig. 7. The hearth rotates, carrying the work around from the charging to the discharging doors. Since these doors are located side by side, one attendant can readily charge and quench the parts.

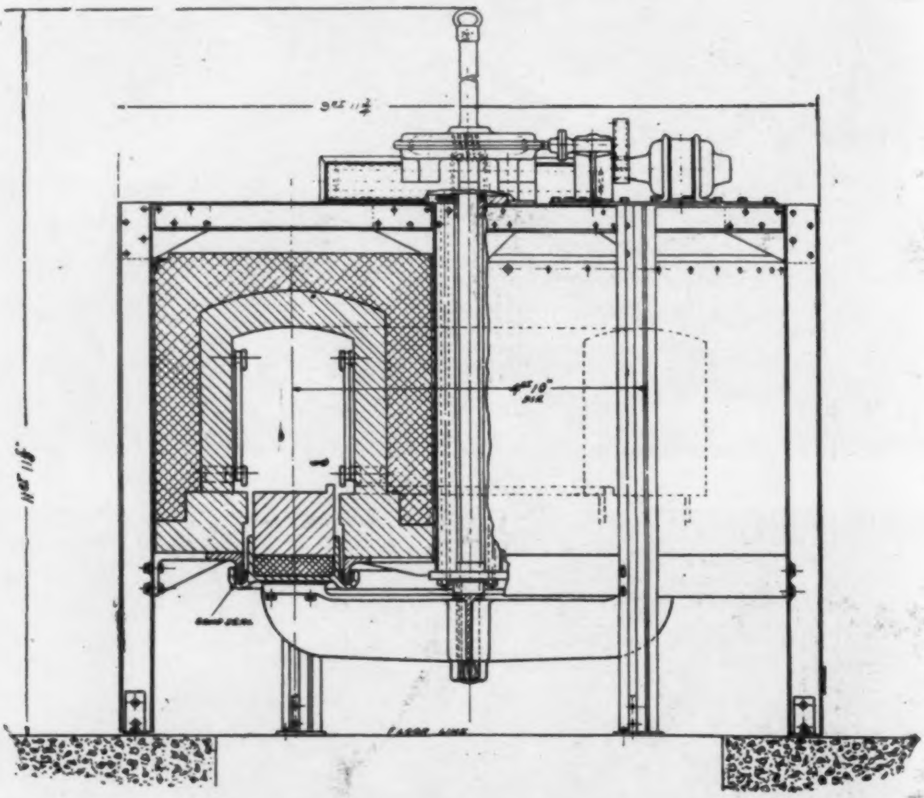


Fig. 7—Outline of Electric Resistance Heat Treating Furnace with Suspended Hearth, Revolvable about the Vertical Axis.

The furnace is well suited to the heat treatment of small parts such as rollers, set screws, etc., placed in containers, since the container can be refilled and returned to the furnace with only a small loss of heat. It is also convenient for heating small gears.

Accuracy of Control Obtained in Electric Furnaces

A good idea of the accuracy of heating can be obtained from a study of the heating curve (Fig. 8) of a gear as it is carried through the furnace. The solid line is the temperature of a couple imbedded in the hub of the gear and the dotted line shows the temperature at a point about six inches above the gear.

The actual operation of several furnaces of this type has resulted in large savings due to the reduction in scaling and warping. Savings in subsequent operations alone have saved two or three times the total cost of electricity. One user of this type of furnace was able to effect a saving of 2½ cents per part on heat treating labor alone, while the total cost of

electricity for heating the part was less than 2 cents. These facts are given to show how the actual operation of furnaces has completely disproved the theory of high operating costs of electric furnaces.

A large furnace (Fig. 9) of this type has been in operation for over a year for heating such parts as front axles, crankshafts, etc. This furnace

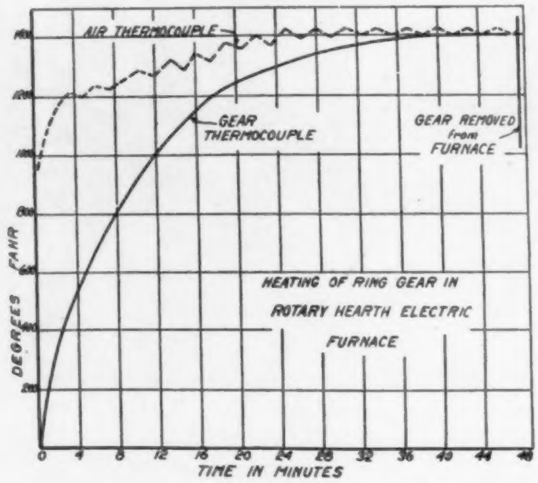


Fig. 8—Time-Temperature Curve of Ring—Gear Heat Treated in a Rotary Hearth Electric Furnace. The Solid Line shows the Temperature of the Gear with Thermocouple in Contact with it. The Broken Line shows the Temperature of the Furnace When a Thermocouple was placed a few inches from the Gear.

has a capacity of approximately 3000 pounds of steel per hour. It is frequently used at night for carbonizing, the entire hearth being filled with carbonizing pots.

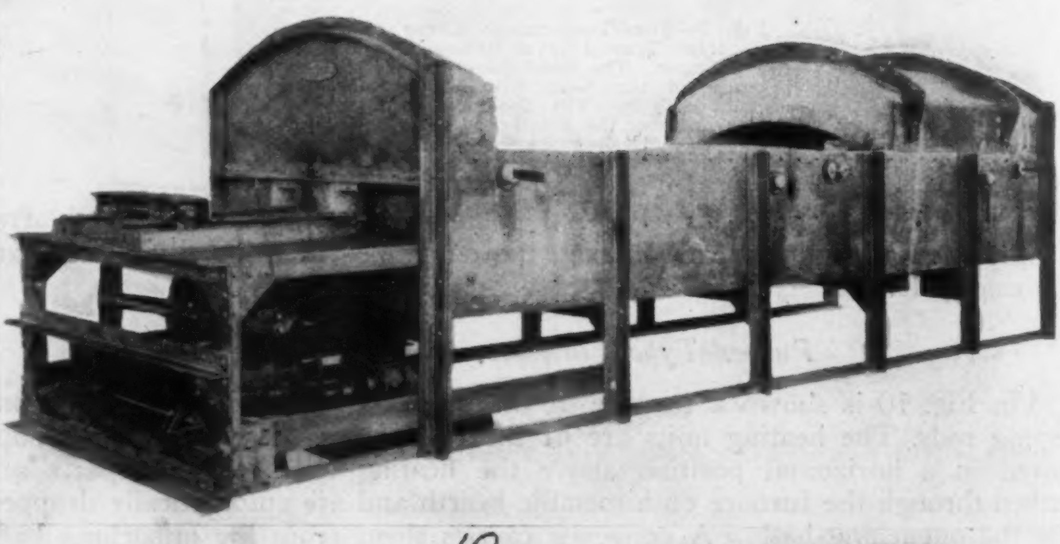
Pusher Type Furnaces Are Adaptable

In Fig. 10 is shown a furnace of the pusher type for heat treating connecting rods. The heating units are of the ribbon resistor type and are supported in a horizontal position above the heating chamber. The parts are pushed through the furnace on a metallic hearth and are automatically dropped into the quenching bath. A conveyor carries them from the quenching bath to the drawing furnace. Furnaces of this type are particularly suited to the continuous heating of similar parts of such a shape that they can be pushed through the furnace without the use of containers.

Where parts are so shaped as to make the pusher type of furnace impracticable, other types of tunnel furnaces are available. In one type the parts are carried through the furnace by means of a walking beam fitted with prongs that project up through a slot in the hearth and step the parts along. In another type of tunnel furnace the parts being heated are carried through the furnace on metal rollers spaced at frequent intervals and slowly rotated.

Tunnel furnaces of these types are well adapted to installation in the line of production in the machine shop. The saving in handling charges alone when so installed will in many cases more than cover the total cost of electricity. The automatic control of temperature and of the time that parts are exposed to the heat gives a uniformity of quality and hardness that results in further savings in subsequent machining operations and in rejections.

9



10

Fig. 9—Interior View looking toward the Charging Door and showing the Baffle Arch between the Charging and Discharging Doors of Electric Heat Treating Rotary Furnace equipped with Automatic Temperature Control. Operating Temperature 1550°F., 3 Phase 440 Volt, Total KW 270. Fig. 10—Pusher Type Furnace for Heat Treating Connecting Rods. Two Chambers below Heating Units. Each Chamber 16′ long, 11″ wide and 8″ high. Connected Load 87KW. Operating Temperature 1650° F.

Large Diversity of Applications of Electric Furnaces

The foregoing illustrations are sufficient to show the diversity of applications to which the electric furnace has been successfully applied. It also shows that there is no one best design that can be applied to heat treating operations in general. The goal in all heat treating operations should be to suit the furnace to the requirements of the parts being heated and the shop conditions—not as has so often been the practice in the past, to suit the parts being heated and shop conditions to the furnace.

ON THE CAUSE OF QUENCHING CRACKS

By Kotaro Honda, Tokujiro Matsushita, and Sakae Idei
(Tohoku Imperial University, Sendai, Japan).

IT IS a well-known fact that during the quenching of high carbon steels in water, cracks are often formed on their surfaces. The cause[1] is generally believed to be:

(a) The non-uniform distribution of temperature in the specimen during quenching.

(b) The difference in martensitic expansion of adjacent parts during quenching.

A closer examination of the phenomenon shows, however, that the true cause is not so evident, as the sound due to cracking is often heard some ten seconds after quenching. The thermal stress is maintained so long as the temperature is not uniform throughout the specimen. For instance, in a short cylinder, about 2 centimeters in thickness and height, the difference in temperatures between the interior and exterior parts, during the first stage of the quenching process, may amount to several hundred degrees, and consequently a great stress will result, but after about ten seconds it does not exceed 20 degrees, and hence there is only a small residual stress. Again, at the moment of transformation of austenite into martensite during cooling, considerable expansion in volume occurs. In the case of rapid cooling the transformation does not, however, take place at the same moment at every point within the specimen. Hence a great stress due to unequal martensitic expansion will result which may lead to cracking, although after several seconds, during which the A1 transformation passes over the whole mass, this stress will also vanish.

If the cracks were due to the two causes above-mentioned, why do they not take place during the first stage of quenching, when the specimen is undergoing a large amount of internal stress, and why do they take place after a lapse of time? It is, of course, conceivable that at a very high temperature the material yields to an enormous thermal stress, and therefore this stress is subsequently released, in which case a thermal stress of considerable magnitude may result at room temperature and may be the cause of the cracks occurring some ten seconds after quenching. The fact that in a high carbon steel, when quenched from a sufficiently high temperature, the cracks are produced immediately after quenching, shows, however, that a greater part of the thermal stress is not released by yielding, otherwise the immediate cracks would not take place at all.

It is a well-known fact that quenching cracks can often be observed in carbon steels or in steels with a small content of other elements, but that it is hardly possible to obtain such cracks in pure metals. These facts lead to the conclusion that the above causes of cracks are not sufficient to account for the observed facts. The present investigation was therefore undertaken to find the real cause of the phenomenon in question.

In order first to show that the cause of quenching cracks is not pure thermal stress, the following experiment was first made: Several cubes, 2

1. McCance, *Journal* of the Iron and Steel Institute, 1914, No. II pp. 235, 247.

A paper presented at the annual meeting of the Iron and Steel Institute, May 5-6, 1921.

centimeters on each side, were made of steel containing 1.26 per cent of carbon, and each cube was attached to the end of a thick iron wire, 2 millimeters thick and 30 centimeters long, by means of which it could be placed in the center of an electric furnace, and be quickly removed for quenching. The furnace was of the resistance type, 25 centimeters long, consisting of a nichrome wire; its temperature was measured by means of a platinum and platinum-rhodium couple. The cubes were quenched in water from different high temperatures, and the quenching temperature at which cracking occurred was observed. If the crack did not occur, the same cube was used twice for quenching, and then renewed; if it cracked, a new one was always substituted.

The following table contains the result of the experiments:

Table I

Heating

Quenching Temperature Degrees Centigrade	680	700	750	770	800	830
Remarks	No Crack	No Crack	No Crack	No Crack	Crack	Crack

Cooling

Quenching Temperature Degrees Centigrade—Specimens first heated to 900 degrees Centigrade, then cooled and quenched	800	770	750	730	710	690
Remarks	Crack	Crack	Crack	Crack	Crack	No Crack

From the above table it is seen that during heating the crack does not occur unless the quenching temperature exceeds 800 degrees Cent. During cooling from 900 degrees Cent. the quenching cracks is always observed down to a temperature of 700 degrees Cent. and not observed at any lower temperature. This limiting temperature is much lower than that during heating. As is well known, the Ar1 point is always lower by about 40 to 80 degrees Cent. than the Ac1 point; hence, from the above result of quenching experiments, it may be concluded that during heating or cooling the crack occurs when, and only when, the quenching temperature exceeds the Ac1 or Ar1 point, respectively. Hence the cause of quenching cracks is not pure thermal stress caused by non-uniform distribution of temperature due to rapid cooling, because if such were the case, there would be no reason for the cracks occurring beyond the A1 point. The cracks must, therefore, have some connection with the A1 transformation.

In a soft quenching, cracks usually occurred in ten to fifteen seconds after quenching in water; they could be distinctly detected by the sounds accompanying cracking. The same fact also indicates that the thermal stress is not the direct cause of cracking because the cracking occurs after a lapse of time, where a greater part of the thermal stress due to the unequal cooling of the specimen passes off. As is well known, during cooling through the Ar1 point the specimen undergoes a considerable expansion due to the A1 transformation.[2] Since during cooling the outer portion is always at a much lower temperature than the inner portion, the former, during the said transformation, exerts a great impulsive tension on the latter, and this may cause a crack in the specimen. But the fact that cracks often occur after the impulsive stress due to the Ar1 transformation is passed over, shows that the impulsive stress is not the actual cause of quenching cracks.

It was also thought desirable to make a similar experiment with a speci-

2. K. Honda, *Science Reports*, Vol. VI (1917), p. 203.

men having no A1 transformation, which was, however, at least as brittle as quenched carbon steels. An alloy steel containing a considerable amount of chromium and cobalt possessed such a property. The experiment with the steel showed that, from 550 degrees Cent. upwards, very superficial but irregular cracks gradually appear, but vanish, however, with a light polishing. As the quenching temperature rises, the cracks become deeper and deeper,

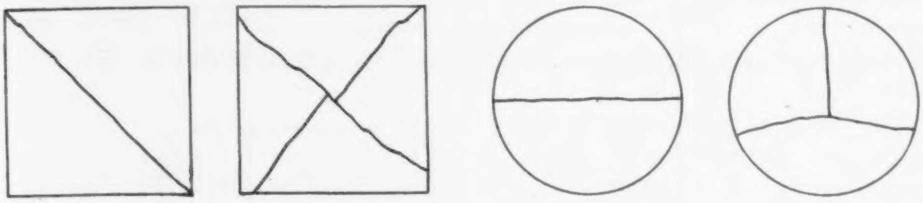


Fig. 1—Crack lines due to thermal stress in quenched carbon steels.

but remain always irregular. Quenched from 1000 degrees Cent. they are still much finer than those in carbon steels. The quenching of a cast iron from different high temperatures shows also similar cracks. Thus, crack lines due to pure thermal stress are very fine and irregular, and can easily be distinguished from very simple crack lines (Fig. 1) in quenched carbon steels, which are the object of the present investigation.

To get a general idea of the rate of cooling during quenching, a cylindrical piece having the same dimensions was made of the same material as the test specimens. It had two holes bored parallel to its axis and to its middle height, their inner diameter being each 2 millimeters; one hole was bored at its center and the other just inside the lateral surface. In one experiment a platinum and platinum-rhodium couple was well insulated and inserted into the middle hole, its junction being, however, bare and in direct contact with the specimen, while the other hole was packed with kaolin. In another experiment the couple was inserted into the side hole while the central hole was packed with kaolin. In each case the cooling was measured by a millivoltmeter with a pivoted needle inserted in the circuit of the couple, the motion of the needle being almost dead beat. Fig. 2 shows graphically the result of the observations. From curves (1) and (2) it is seen that the temperature of the specimen at its center and at its lateral surface falls initially very slowly, and then rapidly, increasing in its rate till it reaches a maximum and then gradually decreases. Curve (3) is the difference-curve between curves (1) and (2); thus the difference in temperatures between the center and the lateral surface is at first zero, but rapidly increases, reaching its maximum value at about 3.5 seconds and then decreases, till it almost vanishes at 13 seconds. The maximum difference in temperatures in the specimen amounts only to about 300 degrees Cent.

The result of quenching experiments will be next described. The investigation consisted of the measurement of hardness in quenched specimens by means of a Shore scleroscope, the distribution of internal stress being thus found. Four kinds of carbon steel containing the following constituents were chiefly investigated:

No.	Carbon Per Cent	Manganese Per Cent	Silicon Per Cent	Phosphorus Per Cent	Sulphur Per Cent
1	.28	.25	.42	.032	.070
2	.68	.51	.19	.019	.037
3	.91	.31	.11	.027	.004
4	1.47	.25	.34	.040	.004

The specimens were tested in the form of a cube, each side being 2.7 centimeters, or a short cylinder, 2.6 centimeters in diameter and in height. On a surface of the cube or the cylinder a narrow hole, about 3 millimeters deep, was bored, and a thick steel wire screwed in, as shown in Fig. 3; this wire served as a holder in the subsequent work. The specimen was placed horizontally in an electric furnace of nichrome wire, and heated to the required temperature. After maintaining the specimen at this temperature

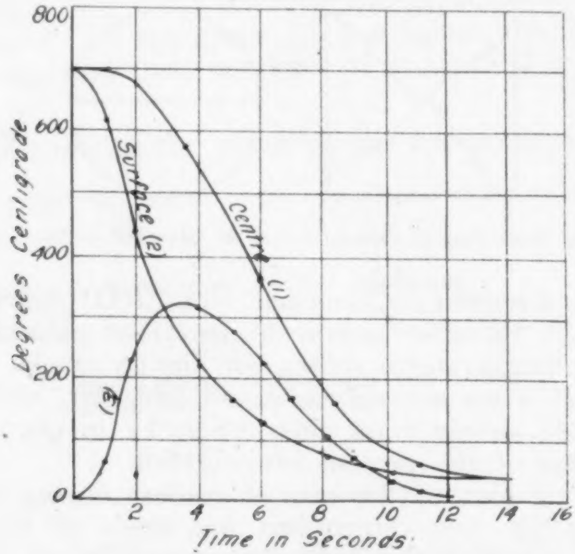


Fig. 2—Curves showing cooling of cubes

for ten minutes, it was quickly taken out of the furnace and dipped vertically into a water or oil bath, followed by a constant stirring, until the temperature of the specimen fell to that of the bath. The specimen thus quenched was polished with emery paper; sometimes it was at first ground with carborundum, care being taken, by dipping it frequently in water, not to heat the specimen too much, since heating may affect the structure and consequently its hardness. The specimen was placed on the platform of a Shore scleroscope, and the position of a point, at which the hardness was to be measured, was read on a section paper pasted on the platform. In the case of the cubes, the number of points by which the hardness was measured amounted to 36, and sometimes more, if necessary. These 36 points were divided into three groups, the outer group consisting of 20 points at the periphery, the inner group 4 points about the center, and the middle group 12 points situated between these two. In the case of cylindrical specimens, the number of points amounted to 24 in all, the outer group being 12, the middle 8, and the center 4. In cases when the general character of the distribution of hardness is to be sought, the mean value of hardness in each group was taken.

The results of experiments showed that:

(1) In a soft quenching, such as in oil from a temperature not exceeding 820 degrees Cent., the hardness of different specimens is greatest in the outer portion, and decreases from its periphery towards the center.

(2) In a medium quenching, such as that of a steel 0.9 per cent carbon at 780 degrees Cent. in water, or that of steel 1.47 per cent carbon at 900 degrees Cent. in oil, hardness is nearly constant everywhere.

(3) In a hard quenching, such as that of steel containing more than

0.68 per cent carbon from 800 degrees Cent. or a higher temperature in water, the hardness is least in the outer portion and increases rapidly toward the center.

(4) When cracking takes place, lines of cracking cut equi-hardness curves almost orthogonally. The form of equi-hardness curves is elongated in a direction normal to the line of cracking.

(5) In the cubes, the equi-hardness lines become roughly circular or elliptical at a short distance from the periphery. The same remark applies naturally to the case of cylindrical specimens.

(6) By grinding away a few millimeters from the surface layer step

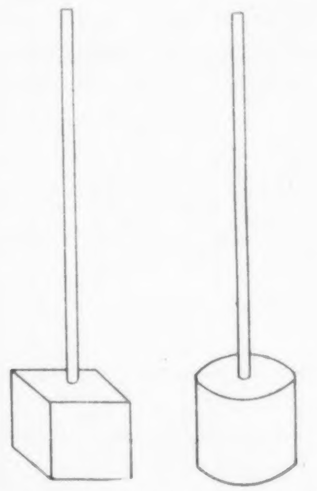


Fig. 3—Sketch showing manner in which specimens were mounted for quenching and hardness tests.

by step, the irregular deviation of equi-hardness curves from a circle or an ellipse gradually diminishes.

In the present experiment, cracking occurred in most cases, when the temperature of the specimens fell nearly to that of the bath. To show the relation between the hardness and the quenching temperature, the results of experiments are given in Figs. 4 and 5, from which the following well-known facts may be inferred:

(7) The hardness does not increase appreciably, so long as the quenching temperature is below the Ac1 point.

(8) When the quenching temperature increases beyond the beginning of the Ac1 range, the hardness rapidly increases, reaches a maximum at about 820 degrees Cent. and afterwards slightly decreases.

From the curves in Figs. 4 and 5 we also see that the hardness of the outer portion is least, that of the middle portion considerably greater, and that of the central portion greatest.

One important fact discovered by the present investigation is that in a hard quenching the outer portion is softer than the inner. This abnormal phenomenon is satisfactorily explained by the theory of quenching put forward by one of the present writers.[3]

According to that theory of quenching, the so-called A1 transformation is not a single, but a compound transformation, consisting of

Austenite to Martensite to Pearlite

Thus, during a slow or rapid cooling, austenite is at first changed into mar-

3. K. Honda, *Science Reports*, Vol. VIII (1919), p. 181.

tensite, which is then transformed into pearlite. During a very rapid cooling, such as a quenching, the change from austenite to martensite is so far retarded that when it is completed the specimen is nearly at room temperature, and therefore the next change from martensite to pearlite cannot progress, owing to the high viscosity of the material at room temperature. During a slow cooling austenite changes into martensite, and the latter, still at a very high temperature, changes immediately into pearlite. During heating, the A1 transformation consists in the reverse change, that is, from pearlite to austenite through martensite.

With regard to the volume per unit of mass, the relation is:

Austenite is less than martensite and martensite is greater than pearlite; for martensite is known to exist in a more dilated state than pearlite, and the latter in a more dilated state than austenite, as is seen from the expansion curves[4] at high temperatures. Hence in the A1 range, during slow cool-

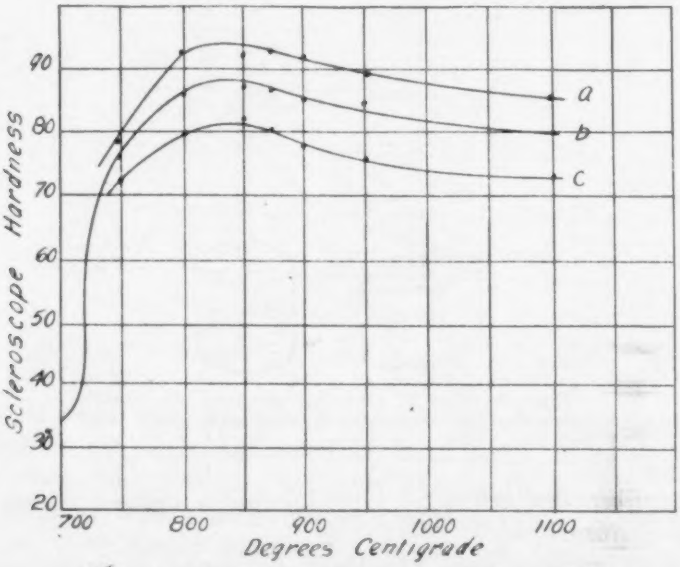


Fig. 4—Curves showing the relation between quenching temperature and hardness of a .68 per cent carbon steel. (a) inner group, (b) middle group, (c) outer group.

ing, the elongation is a differential effect of the expansion due to austenite going to martensite and of the contraction due to martensite going to pearlite; during slow heating, the contraction is a differential effect of the expansion due to pearlite going to martensite and of the contraction due to martensite going to austenite.

In quenching experiments, the rates of cooling in the outer and inner portions of the specimen differ considerably from each other. In the outer portion, where cooling is very rapid, not only the second change of the A1 transformation—martensite to pearlite—is stopped, but also its first change—austenite to martensite—is partially arrested, so that this portion contains a certain amount of austenite intermingled with martensite. In the inner portion the rate of cooling is not so rapid, and hence the austenite is mostly transformed into martensite; but its further transformation into pearlite is arrested. Since the austenitic structure is much softer than the martensite structure, it is to be expected that the outer portion, containing a greater proportion of austenite than the inner portion, will be softer than this portion.

If the above view is correct, for a soft quenching such as quenching in

4. K. Honda, *Science Reports*, Vol. VI, (1917), p. 203.

oil from a moderately high temperature, the outer portion may be just fully martensitised, while in the inner portion the transformation from martensite to pearlite is partial. In this case, the outer portion must be harder than the inner portion, as is actually brought out by experiments. In a somewhat harder quenching than in the last case, the outer and inner portions may possess nearly the same hardness. The fact that above 820 degrees Cent. the hardness gradually decreases as the quenching temperature increases, is explained by the same theory, that is, by a gradual increase of austenite arrested and mixed in martensite.

Several quenched specimens were examined microscopically, to see

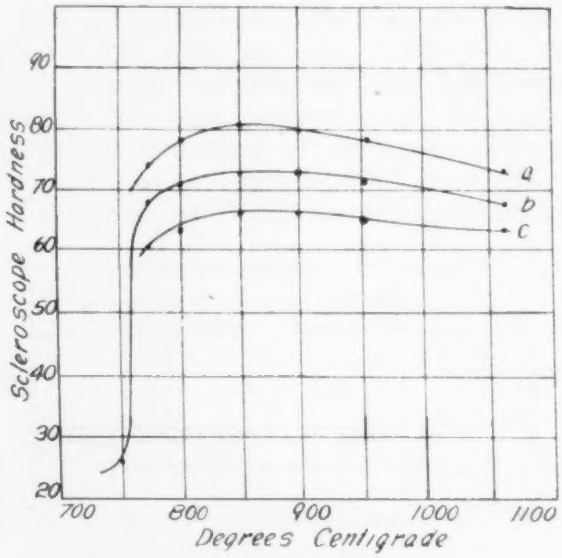


Fig. 5—Curves showing the relation between quenching temperature and hardness of a .28 per cent steel. (a) inner group, (b) middle group, (c) outer group.

whether any appreciable decarburization actually occurred; but except narrow edges, or at least in portions where hardness was measured, decarburization was negligibly small. Hence the less hardening of the outer portions cannot be explained by decarburization. It is the common experience of smiths that by quenching pieces of steel in water, the edges are much softer than other portions; this fact is usually explained as the effect of decarburization during heating. In many cases, however, it is caused by the arrested austenite during quenching.

The cause of cracking was next investigated in a series of equi-hardness curves for a number of carbon steels with varying percentages of carbon, quenched from varying temperatures. These curves accompanied the original manuscript, but as their reproduction would have been attended with certain difficulties, they have been omitted from the paper, and are filed in the Institute library, where they can be consulted by any member interested in the subject. Since the form of the equi-hardness lines was elongated in the direction perpendicular to the line of cracking, it is to be concluded that the martensite development is greatest in the elongated central portion and least in the periphery; hence the martensite expansion in the former portion is much greater than that in the latter portion. The central portion exerts, therefore, a great tension on both sides, this tension causing the cracking of the specimens. This is why lines of cracking are normal to

the elongated equi-hardness curves. Since the difference in the specific volumes for martensitic and austenitic structures increases rapidly as the temperature falls, it may be understood why cracking generally occurs when the temperature of the specimen approaches to room temperature.

Having thus far explained the distribution of hardness and crack lines, the question of how to avoid quenching cracks arises. In quenching practice it is not necessary to get very great hardness, except in the case of cutlery. It is also evident from the above investigation that to obtain a martensitic structure too rapid cooling is unnecessary. In order, therefore, that the specimen may not crack during quenching, but that its hardness be properly developed, quenching must be medium hard, such as quenching in oil from 900 degrees, in which case the hardness is nearly constant throughout the specimen; hence the stress due to the difference in the structures is small, and consequently cracking cannot occur. For a given steel, the quenching temperature of no cracking can be experimentally found in the following way: The specimen is quenched in oil from three different temperatures, 800, 900 and 1000 degrees Cent., and the hardness at the outer and central portions is measured. Two curves of hardness-quenching

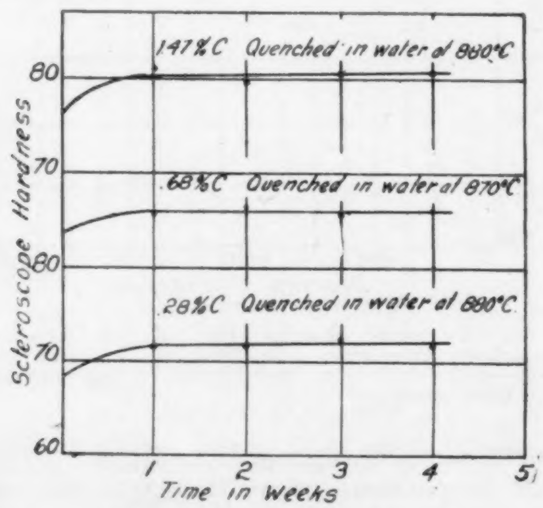


Fig. 6—Graphical representation of experiments to determine the change in hardness of a quenched steel when allowed to stand at room temperature.

temperature for these two portions are drawn. The temperature corresponding with the intersection of these curves is that required; for quenching at that temperature causes nearly equal hardness in the outside and central portions.

According to the above view, in a hard quenched steel some austenite remains untransformed at room temperature, at which this austenite will slowly transform into martensite. On the other hand, at room temperature martensite has a tendceny further to be transformed into troostite, but its velocity is much smaller than that of austenite going to martensite just referred to. The consequence is that at room temperature a hard quenched specimen will slowly increase its hardness with lapse of time. To test this inference the hardness of a quenched specimen was measured from time to time in the usual way, and its mean value plotted against the time passed after the quenching. Fig. 6 is a graphical representation of the result of the experiment, which agrees completely with expectation. The hardness

increases at first rapidly and then slowly, tending to an asymptotic value, as the time elapses.

If the quenched specimen be constantly heated at 100 degrees Cent., instead of letting it remain at room temperature, the above change from austenite to martensite will be much accelerated; at the same time the change from martensite to troostite will also be accelerated. Hence the hardness first increases, reaches a maximum, and then slowly decreases. As shown in Fig. 7, this conclusion is actually brought out by exeriments.

In quenching a large piece of steel the distribution of hardness in the outer layer is exactly the same as in the case so far discussed; but in the

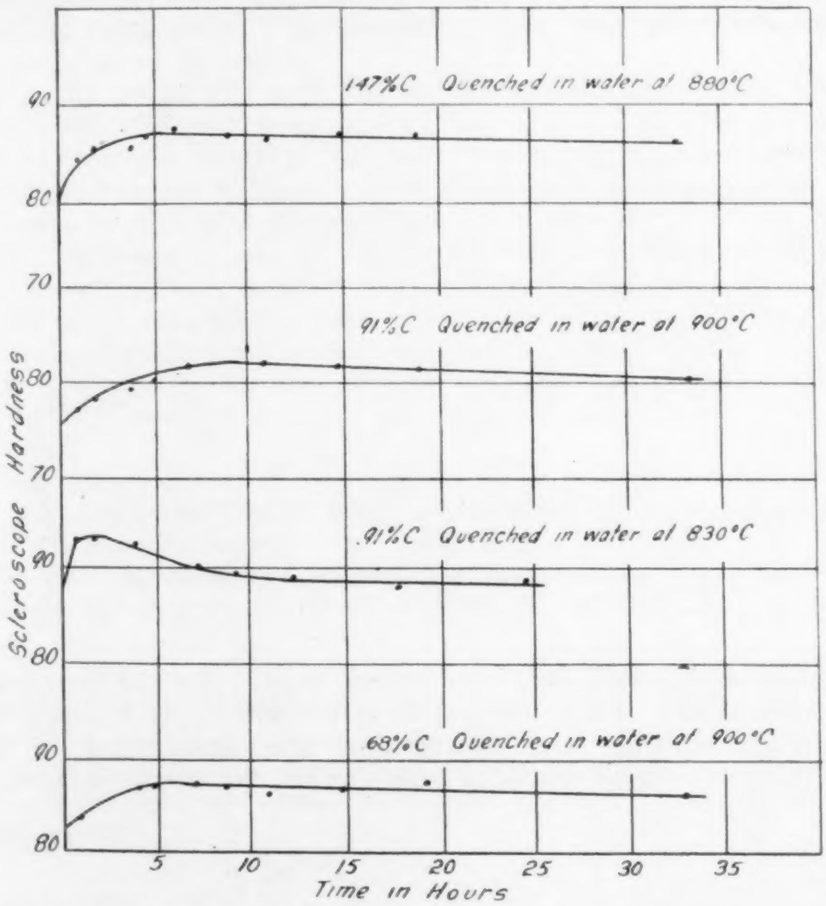


Fig. 7—Graphical representation of experiments where a quenched steel is constantly heated at 100 degrees Cent. The hardness first increases, reaches a maximum and then slowly decreases.

innermost portion, where cooling is slow, the microstructure becomes troostitic, and therefore the hardness is here considerably smaller.

Now, the contraction-temperature curve for steel rod during slow cooling[5] or quenching[6] has been already determined and found to have a form as shown by curve (*a*) or curve (*b*) in Fig. 8. The curve (*a*) is the ordinary contraction-curve for a slow cooling; the curve (*b*) for quenching begins to elongate from 200 degrees Cent. downward, and at ordinary temperature the length of the rod is much larger than that in the case of slow cooling. This elongation is the expansion, accompanying the transformation

5. K. Honda, *Science Reports*, Vol. VI, l. c.

6. Ibid., Vol. VIII (1919), p. 169. P. Chevenard, *Comptes Rendus* (1919), p. 17.

from austenite to martensite, the further transformation from martensite to pearlite being arrested. Hence, in quenching a large specimen, its outer portion contracts along a curve similar to curve (*b*), while the inner portion contracts in a manner similar to curve (*a*), and therefore during cooling through the A1 range the inner portion is in a more dilated state than in the latter portion. Hence the outer portion undergoes a large tension, and this tension superposed on the thermal stress may cause the cracks in the specimen at high temperatures. In a hard quenching, crackings are often found to take place immediately after quenching in water; this kind of crack is probably due to the stress just referred to. By a further cooling of the specimen, the tension acting on the outer portion begins to decrease at some 200 degrees Cent. becoming zero at a certain lower temperature. It then changes

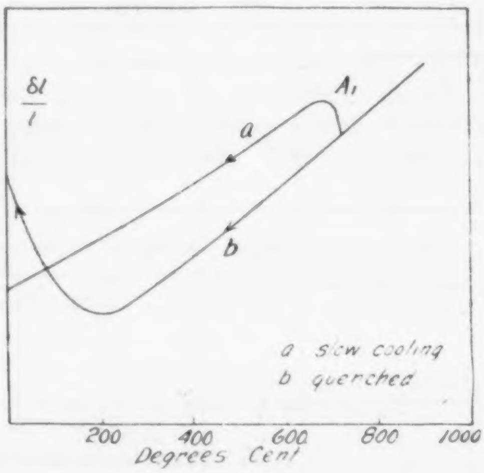


Fig. 8—Curve showing change in stress of a specimen in quenching.

into compression, its magnitude increasing rapidly as the temperature falls to room temperature. These changes of stress will easily be understood from Fig. 8. In approaching room temperature the temperature of the whole specimen becomes nearly uniform, and hence the thermal stress vanishes.

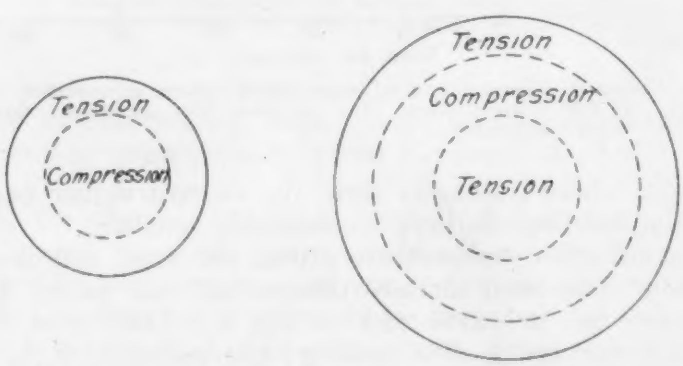


Fig. 9—Diagrammatic sketch illustrating the stresses present in a large and small cylindrical specimen quenched in water.

By virtue of the above stress the inner portion undergoes a tension from the outer portion; this outer portion also exerts a tension to the outmost portion

of the specimen by the strain exerted in the foregoing sections. The result is that the intermediate layer exerts on both sides large tension; if it be sufficiently large, cracking of the specimen may take place in the vicinity of room temperature. Thus the nature of the stress present in small and large cylindrical specimens which are quenched in water may conveniently be illustrated in Fig. 9.

Summary

The result of the present investigation may be summarized as follows:

1. In a quenched steel a certain amount of austenite is generally present intermingled in martensite. The amount of this austenite increases as the quenching temperature increases.

2. In small pieces of steel the periphery is harder than the central portion only when the quenching is very soft. In a moderate quenching the hardness is everywhere nearly equal, but in a hard quenching the periphery is always softer than the interior. This anomalous phenomenon is explained by the presence of the arrested austenite in martensite.

3. The quenching cracks in small pieces of steel occur when the hardness in the central portion is much greater than in the periphery. The cause of the cracking is attributed to the stress caused by the difference in the specific volumes of austenite and martensite; the specific volume of the former structure being much smaller than that of the latter the central portion exerts a large tangential tension on the periphery, causing thereby the cracking of the specimen.

4. Since the difference in the specific volumes increases as the temperature falls, the cracking usually takes place when the temperature of the quenched specimen approaches room temperature.

5. In a hard quenching, the hardness generally increases with the lapse of time, owing to a gradual transformation of the arrested austenite into martensite.

6. In the case of a large specimen, cracking may take place in the A1 range, and also in the vicinity of room temperature. The cracking at the high temperature is chiefly caused by the stress due to the structural difference between the inner and outer portions—pearlite and austenite—just below the A1 point; that at room temperature is due to a similar stress as in the small specimens.

ELECTRIC FURNACE MELTING PRACTICE

By E. G. Stedman

Abstract

Electric furnace production of steel has become a very important factor in the manufacture of high grade steels and the author of this paper has reviewed in a practical way the factors entering into this problem. He discusses the type of equipment he is using, the methods of procedure, including laboratory tests and forge and chill tests used in controlling the melting practice.

The author outlines the casting practice, the ingot forging practice, the rolling practice and the billet piercing practice as carried out at his plant. In conclusion he summarizes the points wherein he believes that electric furnace melting practice surpasses that of the open-hearth practice.

FOR those who are unacquainted with the general layout of an electric furnace steel plant, adapted to the production of finished seamless tubes from the raw material, the writer has endeavored to outline briefly the equipment and the procedure necessary for their production.

The steel producing department of the company with which the writer is connected was installed primarily for the production of steel to be used in the manufacture of their own product, namely, roller bearings—the steel required for their manufacture being what is known as carburizing steels, consisting of two grades (both low carbon), one grade containing one per cent chrome; the other .50 per cent chrome. By producing our own steel, a very close watch can be kept on it from the raw to the finished material.

Equipment Used

The electric furnace melting department consists of the following: four 6-ton basic Héroult electric furnaces, using 22,000 volts, three-phase primary, transformed at the furnaces to 110 volts, operating on 17-inch diameter carbon electrodes; two 20-ton cranes; an hydraulic stripper, etc.

The press department consists of one 625-ton hydraulic press; one 3000-pound manipulator, in addition to two 2-hole combination oil or natural gas fired soaking pits. Also, a bar mill consisting of one 22-inch Standard Engineering four stand, three high mill; tilting tables; continuous furnace, hot bed, hot saw, etc.

Procedure of Manufacture

The steel produced by this equipment is made from scrap especially selected as to its physical character and chemical analysis. After having been rigidly inspected and passed upon, it is unloaded by magnet in the electric furnace building, and is brought up to furnaces as required after being reloaded in scrap skips,—the contents of two of these skips being sufficient for one entire heat. These skips are first weighed and placed opposite charging doors of furnaces before the previous heat is tapped—this to facilitate the charging operation which begins immediately after the heat has been tapped and bottom made up.

A paper presented before the Detroit Chapter. The author, F. G. Stedman, is connected with the Timken Roller Bearing Co., Canton, O.

All charging is done by hand and it requires approximately thirty minutes to put in the entire charge. It might be added that this scrap is used in proportions of 50 per cent of what is known as heavy scrap and 50 per cent turnings. The power is then applied at the rate of 500 to 600 kilowatts per phase for approximately 2½ hours, after which time the bath is completely melted down. At intervals, however, during this melting-down period, the scrap must be broken loose and pushed away from the banks toward the center of the furnace—this to facilitate the time of melting-down period—as the greatest heat is obtained in the immediate vicinity of the electrodes which are in the center of the furnace. After the scrap is all melted down, the power is reduced to approximately 200 kilowatts per phase until such time as the first or dephosphorizing slag is rabbled off.

Laboratory Tests to Determine Composition

Before this slag is removed, a test is taken and forwarded to the chemical laboratory for the determination of carbon and manganese. However, before this test is sent to the laboratory, it is fractured and the carbon read by the furnace operator. If, in his estimation, the carbon is too high, the bath is *scaled* down to the required carbon content. In the meantime, a check on the fractures, as read by the melter, is obtained from the laboratory and the heat is now ready for the removal of the dephosphorizing slag which is done by the use of wooden rabbles, requiring for this operation approximately ten minutes.

In the event of the carbon being too low at this stage of the heat, a recarburizer in the form of coal or coke is added immediately after this slag is rabbled off. The final or finishing slag is then applied to the bath in the following proportions: 400 pounds of lime, 30 pounds of silica sand and 20 pounds of fluor spar. Power is again applied at a reduced rate, melting this slag in approximately ten minutes, after which time coke dust and fluor spar are added and the heat worked until such time as a calcium or carbide slag is obtained.

Another test known as the preliminary is then taken from the bath and forwarded to the laboratory, determining from this test the carbon and manganese content. Up to this time, in the making of ordinary steel, carbon and manganese are held at a point slightly below that required by the specification, after receiving determinations on these two elements, the final addition of pig iron is then made to bring the carbon content to the low side of the specification. These latter additions are then allowed sufficient time for melting and becoming thoroughly permeated through the bath.

Forge and Chill Tests Important

A forge test is then taken from the bath to determine the condition of steel before the addition of silicon is made. If, in the estimation of the melter, the steel is in a thoroughly deoxidized condition, the silicon is then added, allowing approximately twenty minutes for this to become absorbed, during which time the heat is poled, making absolutely sure that the silicon is evenly distributed throughout the bath. Another forge test is then taken. If this latter test forges perfectly, the heat is then ready to tap, providing the temperature is correct,—this being

determined by what is known as a chill test. This test is made by the removal of a certain quantity of metal from the bath, noting the amount of time in seconds consumed in chilling.

Situated immediately across from the electric furnaces is the pouring platform, in front of which the molds are placed. A depressed brick and concrete base runs parallel to the entire length of the platform. On this base are set the stools,—the latter being of cast iron with a 13-inch offset to accommodate what is known as a stool tile. The tiles used are first washed with a solution of molasses and graphite; they are then placed in a heating oven, the temperature of which is sufficiently high to remove any moisture that they might contain. The molds are then set up, having a quarter inch clearance all around at the base, this being bound by a thin layer of silica sand. The molds used are of the inverted type, the top dimensions being 16¾ x 16¾ inches and the bottom dimensions 13¼ x 13¼ inches giving a taper of 3½ inches in 5 feet. On all molds there is used a hot top, this top extending down into the mold 5 inches and protruding above 7 inches. All ingots are poured to within 1 inch of the top and a thin layer of refractory material is placed on the ingot immediately after it is poured. The ingots are then allowed to stand in the molds at the pouring platform for not less than one hour, which allows sufficient time for solidification. They are then placed adjacent to the soaking pits, being allowed to remain in the molds until such time as they are charged and at no time are they turned upside down or allowed to lie on their sides. There are two sets of molds which are used alternately to insure proper temperature, and they are thoroughly washed on the inside with a solution of molasses and aluminum before being set up. This wash, after drying, prevents the steel from sticking to the mold walls during the pouring operation. By allowing the ingots to remain in the molds until such time as they are charged much heat is retained which would be lost by stripping or shaking out and allowing them to become chilled.

The ingots are removed by the stripping crane, being pulled directly out of the molds and placed in the soaking pits—eight in a pit, four parallel to each wall. After charging a pit, the temperature of the pit and charge is allowed to equalize, that is the temperature of the ingot and the pit is brought approximately to equilibrium before the gas or oil is applied. The first stage of the heating operation consists of applying the gas and air in proportions to form a heavy scale, after which time the heating operation can be continued at a more rapid rate. The entire heating operation of one individual pit will require approximately 3½ hours where hot ingots are charged.

Forging and Rolling

The ingots, after heating, are removed to a position immediately in front of the press, being held by the manipulator on the small end, the top portion being drawn out first to the required size, which is 8 x 9 inches and the discard cut. The ingot is then turned by the manipulator, and the bottom portion is forged down. From the ingot, which weighs approximately 3500 pounds there are cut two blooms of the above mentioned size, weighing 1485 pounds each. It might be added that this press is run to a capacity of approximately 175 tons of ingots for each twenty-four hours.

The blooms, after being sheared at the press, are then stacked in the mill and allowed to cool, after which they are removed to the chipping yard. By the use of a monorail crane, they are taken from the mill, weighed and piled. They are then pickled as required, chipped and inspected. After chipping and inspecting, the different compositions of steel are piled separately, awaiting removal to the mill for rolling into the following range of sizes: 1¾ to 7 inch squares and 2 to 6½ inch rounds.

These blooms when brought into the mill are again weighed and placed on a platform at the rear end of the continuous furnace. They are then pushed through the furnace by the use of a worm driven pusher, the heating operation requiring approximately two hours. They are then removed from the discharge end of the furnace by means of a cable driven pushout machine onto a table known as the transfer. From this transfer table, they are carried to the first tilting table being fed from this into the first set of roughing rolls.

Piercing

After leaving the mill from the finishing pass onto the runout table they are stamped with the heat and bar number,—this is put in various places to insure no loss of identity, as the bars are cut into multiple lengths at the hot saw which is situated at the end of the runout table. After being sawed to lengths, the bars are allowed to cool; they are then pickled and chipped and forwarded to the tube mill for the piercing operation, which consists of heating, piercing, rolling on reducing mill, annealing, cold drawing, and cutting into finished lengths for the automatic machines.

Advantages in the Use of Electric Steel

Having outlined previously in a general description a plant and equipment for the manufacturing of automotive steels we will now deal in a limited way, as to reason we use electric steel exclusively. In the manufacture of our product, quality is the first consideration in all operations, therefore, for a concern whose chief aim is quality, to be able to follow its product through all the various fabrications, it is a valuable asset to be able to manufacture our own steel from the raw to the finished product.

You may now ask why we adopted electric furnaces in view of the fact that it costs so much more to produce electric steel than it does open-hearth steel. These queries may well be answered by showing the advantages of electric furnace steel over open-hearth steel.

1 It makes heat available very quickly and at will, owing to regulation of power input.
2 Unusually high temperatures may be obtained due to the extremely high temperatures obtainable with the electric arc.
3 More even regulation of heat, due to the automatic regulators.
4 Desired temperatures may easily be obtained and held, due as previously stated to automatic regulation.
5 Cleanest of heating agents, as no sulphur or other undesirable elements are introduced into the furnace through the heating medium.

6 Oxidizing, reducing or neutral operations may be obtained at will.
7 The electric process is the only one in which impurities are not added to the steel by the operation, such as oxygen in the gas in open-hearth practice, impure iron in the crucible, etc.
8 The only positive means of removing the undesirable element sulphur and deoxidizing at the same time.
9 The addition of alloys in the furnace instead of in the ladle as in open-hearth practice.
10 Melting of alloy steel scrap and producing a product of high quality without loss.
11 A steel with unusual wearing qualities from a standpoint of abrasion.
12 Smaller heats may be made than in the open-hearth, thereby better mixing and control.
13 Steels more free from slag inclusions, segregations, etc., due to more thorough deoxidization.
14 A more ductile steel at low temperatures, as arrived at several years ago, under an extensive test conducted by one of the steel corporation plants.
15 A much more uniform steel from a carburizing standpoint.

From a metallurgical standpoint we might now discuss the procedure of making a low carbon chrome heat, carrying .50 per cent chrome. Let us assume that the charge is all in the furnace and melted down, the next step being the removal of the dephosphorizing slag, leaving the bath after removal of the slag with a phosphorus content of .02 which as a general rule is sufficiently low for most specifications. During the first or melting-down period you naturally have a low temperature in the furnace which is beneficial because phosphorus is not readily oxidized at high temperatures in the presence of carbon. We now have a bath of steel analyzing approximately as follows: carbon .06, manganese .15 phosphorus .02, sulphur .05, adding at this time about .35 manganese, and .50 chrome. Slag is then put on in the following proportions: 400 pounds lime, 30 pounds spar, 20 pounds of coke dust. The power is raised at this time to approximately 300 K. W. per phase. About 15 minutes is allowed to elapse at which time the finishing or desulphurizing slag is thoroughly melted, the power may then be reduced, also during this period the bath is completely deoxidized by the frequent additions of carbon, the sulphur content is also reduced at this time as calcium sulphide from the lime and carbon, and manganese sulphide from the manganese. At this time a test is taken for the determination of manganese, and a furnace operator reads the carbon content from the fracture while the slag is held in the proper shape. At this time a sample of slag is taken which upon cooling shows a decided brown cast which indicates that the steel is well deoxidized, however, not completely so, therefore, small proportions of slag consisting of slack lime, fluor spar and coke are added until such time as a slag known as calcium, which is pure white and powders when exposed to the air, or a slightly grayish slag which when added to water generates a carbide odor, is obtained as either of the above is an indication that the bath is thoroughly deoxidized.

The manganese determination has by this time been received from the laboratory and perhaps shows a content of .40 while we were aiming at .55. The other 15 points are now added and well poled into the bath, however, extreme care must be taken when poling especially if the carbon is on high side of specification at this time as a mixing of slag which is highly carbonaceous will have a tendency to raise the carbon in the bath. Silicon can now be added allowing approximately 10 minutes for this element to become thoroughly permeated throughout the bath.

The heat is now ready to tap providing the temperature is as desired and is determined differentially by furnace operators. Let us assume that we are tapping on the cold side, for this test a spoon is well coated with slag, and while extremely hot, a spoonful of metal is removed from the furnace, placing the spoon on the floor and after removing the slag on top of metal, the bare metal will show a boiling or revolving motion for say 15 seconds at which time it will skull over. This is known as a chill test and is as accurate a test as any, to my knowledge. However, account must be taken that all conditions are uniform, such as temperature of the spoon, location in furnace from which metal is taken, whether on banks or from under electrodes, etc. One more spoon test must be taken and poured into the regular test mold and if the metal lays quietly, the heat is in good condition, and thoroughly deoxidized, and if good care is taken in the pouring and teeming, a good product should be the result.

It might be added that where an organization who has been trained in the making of the same composition steel day in and day out, that they naturally become more efficient in the making of high quality steel than an organization who is making a different composition steel on every heat.

Discussion Following Mr. Stedman's Paper

Mr. McCloud: I think it a great advantage to be able to hear a practical man talk on a subject like this. I am aware that the first time one gets into trouble they are apt to blame some operation of which they know nothing for their trouble, and I think it is always an advantage to be able to hear someone talk on the practical phase of an operation with which we are not directly connected, and I am sure we want to thank Mr. Stedman for his talk.

Are there any questions in connection with this paper?

Mr. Stedman: Being somewhat in the dark as to the method of procedure at your meetings, but having been advised that there are a great number of practical men present, I have therefore endeavored to prepare this paper in a practical way. The methods outlined are regular methods of practice and naturally one who is working along the same lines day in and day out does not deal with the details in a discussion of this kind to the extent that perhaps he should in talking to a group of men who are unacquainted with all of these processes.

Question: Why do you use oxides?

Mr. Stedman: Oxides are always included in the scrap charge in the form of scale. Where a carbon reduction is necessary after the melting down period, it is then added in the form of scale or ore.

Question: Then you have to take the oxides out again?

Mr. Stedman: They are automatically removed during the final period.

Question: Are a part of the oxides which are added reduced into metal?

Mr. Stedman: Yes, there is a metallic content to both ore and scale. Of course, this reduction back to the metallic state depends upon the manner in which the oxide is added and when it is added.

Question: Which form of oxide do you prefer to use?

Mr. Stedman: Scale in the electric furnace and ore in the open-hearth.

Question: Do you remove all of the scale?

Mr. Stedman: We have just discussed that in respect to the melting down operation, however, the pressing or rolling-in of scale whereby pick-iing will not remove it can be almost wholly eliminated in the case of the pressing operation by the use of an air blast on the press die. This operation would not be practical in the rolling operation, especially on blooms, billets, bars, etc. However, I might add that salt lightly spread on the surface of plate steel just before the finishing pass is very beneficial, and I have also seen burlap sacks used where an extremely smooth surface is desired.

Question: You stated that you prefer to tap heats on the cold side. Just why do you prefer this?

Mr. Stedman: Personally, I prefer to tap heats on the cold side, as I have experimented extensively as to tapping temperatures. I can give no concrete explanation of this, except that we get a product more free from small seams. Another benefit that may be derived from tapping on the cold side is the longer life of ladle linings. I will admit, however, that a number of steel makers insist upon tapping on the hot side, holding the heat in the ladle to allow the elimination of gases. This would indicate, to my way of thinking, that the heat coming out of the furnace was not thoroughly deoxidized. It is true, however, that a certain amount of oxygen is carried into the molds in the pouring operation by the stream, therefore, I think it very beneficial to use the smallest nozzle possible. The item of tapping temperature has been discussed a number of times and no doubt we will always disagree, as we have in the past as to temperature.

Question: What temperature would your pyrometer show in pouring low carbon steel heats such as you make?

Mr. Stedman: It would show approximately 2700 degrees Fahr. on low carbon steel.

Question: Is it imperative to coat your molds with some type of wash?

Mr. Stedman: Yes, to my mind this is very important. I have experimented with a number of different mold washes in the past, and have obtained the best results with a solution of molasses, aluminum and water. However, the good results obtained are not entirely due to this wash, but to the temperature of the mold when washed, which is very important, as the mold temperature has a tendency to burn out one ingredient, leaving the other. The use of different coatings, I think, is best determined by the kind of steel you are making, facilities for applying same, etc.

Another thing to be taken into consideration in a mold wash is

a grade of material that will resist the splashing which naturally occurs in the pouring operation from sticking to the mold wall.

Question: I would like to ask where you get the steel for the Timken plant?

Mr. Stedman: At one time we had sufficient ingot capacity in our own plant to supply all our material needs, but at the present time it is necessary to resort to outside sources.

Question: Do you use the direct forge method?

Mr. Stedman: Yes.

Question: What if the forge bar breaks?

Mr. Stedman: That would indicate that the steel was short, the manganese being too low.

Question: Do you read carbon on the forge test?

Mr. Stedman: No, a separate test is taken for this purpose. The forge test is poured in a round mold to facilitate handling.

Mr. McCloud: Evidently it is quite surprising for anyone the first time they watch the operation around a steel furnace to see how closely the operator can read the fractures and determine the carbon of the heat. Few men that have never been around a furnace can realize how accurately this can be done.

Question: Where was the first successful electric furnace operated?

Mr. Stedman: I think Halcomb claim that. Is that true Mr. Atkinson?

Mr. Atkinson: I think this is an established fact that Halcomb was first on tool steel, Lebanon on steel castings and South Chicago on large ingots.

Question: May I ask why you cast such large ingots?

Mr. Stedman: To get more reduction and obtain two blooms of the size that we require for our mill.

Question: Is it true that your molds are tapered?

Mr. Stedman: Yes, they are tapered from top to bottom, this taper being on the inside. The wall thickness at the bottom being 5¾ inches and at the top 3 inches.

Question: During the war there was considerable discussion as to flaky structure. Are you troubled with this condition?

Mr. Stedman: No, I think that was entirely confined to the plants making gun steel, and we made no gun products whatever.

Question: How does the cost of producing steel with the electric furnace process compare with that of the open hearth?

Mr. Stedman: It is cheaper to produce than open-hearth, naturally.

Question: I mean actual cost of production?

Mr. Stedman: For the sake of argument, I will say that comparing two efficiently operated plants there would be a variation of approximately $5.00 per ton, but when you take into consideration the uniformity and superior quality of electric steel, I think it can be said without a question that an electric steel can be made as cheaply as open-hearth steel.

Question: In regard to scrap free from oxide and scrap covered with oxide, which do you consider most beneficial?

Mr. Stedman: Scrap heavily covered with oxide is beneficial in making low carbon steels, as the oxide which would have to be added

in the making of high carbon steel is more evenly distributed throughout the scrap.

Mr. McCloud: You mean so far as your operations are concerned, in making a heat of low carbon steel it would be somewhat of an advantage to have rusty scrap?

Mr. Stedman: One drawback, however, in using very rusty scrap is the fact that you buy oxide, paying a steel scrap price for something that can be bought for about 60 per cent less.

Unannounced Speaker: We had a talk last winter by a man who claimed to be an authority on that subject, who made a statement that all the trouble in the manufacture of steel was caused by rusty scrap.

Mr. Stedman: I do not agree with the gentleman, whoever he might be, as I have experimented extensively with different grades of scrap and find that a full charge of scrap heavily covered by oxide, properly worked in the furnace, you can produce steel as good as a full charge of perfectly clean scrap.

Question: Are electric furnaces always basic, or sometimes acid?

Mr. Stedman: To my knowledge no furnaces on the production of ingots are acid, this being due to the character of the scrap, which is used. In making castings most furnaces are acid lined.

Question: Is there any advantage in using an acid lined furnace?

Mr. Stedman: If you are not held to a low sulphur and phosphorous content, I would say yes, due to a slightly higher production, as there is no question but what acid steel can be made with greater speed and also the fact that you do not add ferrosilicon, which is an expensive addition.

Question: How closely do you control your carbon content?

Mr. Stedman: Our specifications call for between 15 and 20 points.

Question: What is the carbon content of the case in a finished bearing?

Mr. Stedman: I would say that it is approximately 1.00 per cent, of course, as you understand, the core remains as originally, stated 0.15 to 0.20 per cent.

Question: In the washing of molds just how is this wash applied?

Mr. Stedman: We use a brush.

Question: Would it not be better to spray this on?

Mr. Stedman: We tried out the spray, but found there was a considerable loss, as spraying was much too fast.

Question: Do you use standard aluminum?

Mr. Stedman: No, we use what is known as "varnish aluminum," which when rubbed between the fingers has the appearance of paint.

Mr. McCloud: Is it the same aluminum that is used on radiators, etc.?

Mr. Stedman: Yes.

Mr. McCloud: How does the length of life of an electric furnace compare with the open hearth?

Mr. Stedman: An electric furnace has to be relined more often.

Mr. McCloud: The question being brought up, I wonder if anyone here knows anything about a controversy in difference of opinions as to acid and basic lined furnaces. I believe that a certain amount of reason for the difference in practice depends upon local supplies. For

instance, I believe the general American practice in production of open-hearth steel is in the basic furnaces, but understand that European practice is the reverse, the same being true with the bessemer practice. I was of the opinion that the larger portion of bessemer steel in this country was made in an acid converter, whereas, on the other side it is made in basic converter.

Unannounced Speaker: The answer to the converter problem is very simple. There were practically no iron works running basic converters in this country a few years back, as the slags were used for phosphorous fertilizer. I know of one company in this country, who have for a considerable time ran two furnaces on acid and one on basic, their reason being that they could balance up their products, which were castings, as to specifications. As a rule acid open-hearth practice is more simple than the basic, but the basic enables one to reduce elements which you could not reduce in the acid furnace. In other words, basic opens to you an old line of refining.

If you attempted to refine in the acid furnace as you do in the basic it would naturally chew the lining out. It is largely a question of the product you have to produce.

Mr. Atkinson: Has anyone here made any considerable number of tests on steel made in both basic and acid open-hearth furnaces, also is there any difference in the steel?

Unannounced Speaker: I do know that during the war both the French and British governments allowed 0.05 per cent lower carbon for acid than for basic steel.

Question: For shell steel?

Mr. Stedman: Yes.

Mr. McCloud: For the same carbon content, would it be possible to obtain higher physical properties from acid steel than basic steel?

Mr. Stedman: Yes, the physical properties would run slightly higher.

TOP DISCARD IN ITS RELATION TO QUALITY

By A. E. White

Abstract

The author of this paper makes an appeal to the steel mills to increase their tonnage output by adopting methods and devices for reducing the amount of piping and segregation, thereby increasing their total yield per ton of metal cast into the ingot molds.

During the World war the government required that a 25 per cent top discard be taken from each ingot rolled into shell stock. In numerous cases it was shown that a lesser amount of discard resulted frequently in defective finished billets.

It has been shown that the mills can work to rigid specifications without experiencing any undue hardship after they adjust their conditions to meet the demands of the specification, with the result that they reduce their spoilage and increase their quality.

Introduction

WE ALL object to the use of alibis by others. Yet who is there who has not used them to a greater or a lesser degree in the days gone by? Many believe that within reason their use may be warranted. We have in our midst those who would not use an alibi to conceal fault or sin, yet would use one if by doing so they believed they would prevent pain or grief.

What is true of individuals is true, within certain limits and at certain times of business. Fundamentally, business, be it large or small, is honest. There are times, however, when alibis have been employed both consciously and unconsciously.

In the steel industry we have accepted for so long a time the various alibis explaining the reasons for imperfections, that we have come to believe them more or less as truths. We have really come to believe that it is necessary for us to take a certain amount of the bad with the good when purchasing steel. We have come to believe that every failure to receive good steel has had a satisfactory explanation.

In the days preceding the World war, we accepted as truth that it was impractical to put into effect certain items of control which would result in the procurement by the consumer of nearly perfect stock. The difficulties surrounding satisfactory inspection were so forcefully presented that we believed it would be impossible to get a better grade of stock—commercially speaking—than we were then receiving. Our friends, from across the water in the procurement of their munition steel, showed us the alibi and proved that adequate inspection at steel mills could be conducted without a fundamental reduction in output.

Immediately after the war, in the period of frenzied business, the alibi for lack of quality was laid at the door of the large number and size of the orders on the books of the steel mills. In 1921, at a time when the normal person would have assumed that it would have been possible to surround the production of steel with every safeguard, we found certain of the mill interests

A paper presented before the Pittsburgh chapter of the society. The author, Col. A. E. White, is director of the department of engineering research of the University of Michigan, Ann Arbor, Mich.

presenting a further alibi, namely, they claimed that because of the reduced business, because of discontinuity of operation and troubles resulting from a somewhat disorganized personnel, they were not able to make as high a grade of steel as they would make when conditions were more favorable for the smooth and frictionless running of their plant.

To those philosophically inclined, what will be the alibi presented when the steel industry has again returned to normal and when it is neither beset by the hectic days of yesterday nor the somewhat uncertain state of today?

Do not misunderstand the nature of these remarks. They are not made as charges against our steel mills. There is no more honorable business in the world and the general policies, principles and procedures are sound and straightforward. The alibis presented are, in the main, accepted as truthful explanations of the failure to meet a hundred per cent perfect output. Is it not possible, however, that both the steel producer and the steel consumer is deceived by the apparent truth of the alibis? It has been pounded into our very being for so many years that we cannot expect to get absolutely homogeneous steel, that we have come to believe that that condition actually exists. Accepting it as a truth, the consumer places before the steel mills his bill of materials and oftentimes places his contract with the firm that has made the lowest bid. This may or may not be good business. It is my personal belief, however, that to place a contract merely on the basis of cost and delivery and even general integrity of a firm without stating anything relative to freedom from piping, segregation, surface defects, etc., is trusting altogether too much to blind instinct.

Suitable Specifications Necessary

There are uses for steel which require most critical inspection. Adequate specifications for the purchase of this stock should be used. There are places where steel with inherent piping and even segregation can be used without fear of failure. Specifications should be used in this case. For the former it is assumed that a higher price would have to be charged than for the latter, for it cannot be expected that a steel mill can operate without profit and the greater care required and the greater losses involved in the production of good steel must necessarily be paid for by the consumer. The consumer should in the end profit by such increased expenditure because he should run into less operating difficulties in the various component parts in which he uses the steel and encounter, therefore, less delays and less losses as a result. For, after all is said and done, the major losses involved by the use of an imperfect steel are borne by the consumer, usually five or ten times over, even though the steel mill does willingly replace the defective product.

Inherent to a greater degree than any of us appreciate, are the troubles due to insufficient discard. For instance, during the World war one of our plants manufacturing rifle barrels was encountering much difficulty in their steel because of excessive dirtiness. On examination we found that the steel used for this purpose was undergoing a top discard of only 15 per cent, whereas steel differing but slightly in composition and costing one-fourth less was undergoing a minimum top discard of 25 per cent. When this situation was brought to the attention of the steel mill they very graciously increased their minimum top discard on the rifle barrel steel to 25 per cent with the result that the delays and losses experienced at the plant almost immediately dropped to zero.

Government Specifications

On shell steel the steel manufacturers were allowed considerable latitude with regard to composition. They were given 20 points variation leeway in carbon and equally wide latitude in manganese. They claimed that such latitude was necessary if they were to furnish the requisite quantity of steel required. This statement may be true, though if I remember correctly there was one mill located not far from Pittsburgh which kept practically every heat it made within five points in carbon and in manganese contents.

The specifications required a minimum top discard of 25 per cent and it was standard mill practice in addition to take a bottom discard of five per cent. The mills were permitted a lower minimum top discard on the submission of evidence that such a step would be justified. As a matter of passing

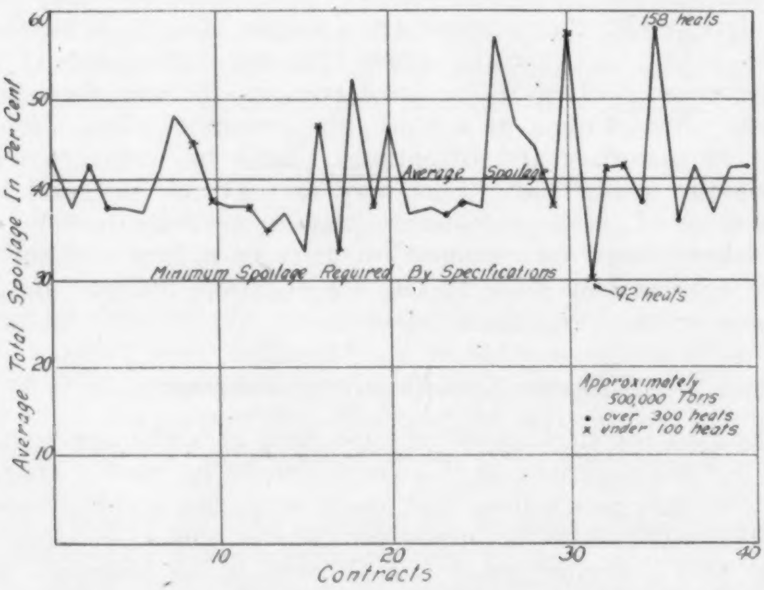


Fig. 1—Average Spoilage On Forty Contracts For Shell Steels

interest, only two mills asked for a lower minimum top discard. One of these requests was granted for about three months but was removed at the end of that time because the average mill practice did not warrant a minimum top discard below 25 per cent. The other mill was advised that on the submission of proper evidence their request would be considered. After six months had elapsed I asked the company's representative why we had not heard further from them with regard to their request for a reduction in top discard and I was informed that on looking into the matter more carefully they found that they would not be justified in presenting their request for reduction.

Spoilage on Shell Steel

I have plotted for our consideration the spoilage from 40 contracts of shell steels representing approximately 500,000 tons—see Fig. 1. The average spoilage for all of these contracts was 41.33 per cent. This is 11.33 per cent above the minimum spoilage required by the specifications. Those firms making over 300 heats have been represented by a solid black circle and those firms making under 100 heats have been represented by crosses. This designation was employed in order to ascertain whether or not the firms making

the larger number of heats had a lower spoilage than the firms making a smaller number of heats. There seems to be no striking evidence in this connection one way or the other. Apparently, therefore, the matter of spoilage is not a question of the number of heats. As a matter of interest that firm producing its quota of steel with the minimum total spoilage—namely 30 per cent—made but 92 heats, whereas a firm producing 158 heats of steel had a total spoilage of 58.7 per cent.

Shell steel was inspected more rigidly than is the case with most commercial steel, though not more so than to insure freedom from piping and undue segregation. Yet one cannot look at the curves found in Fig. 1 and

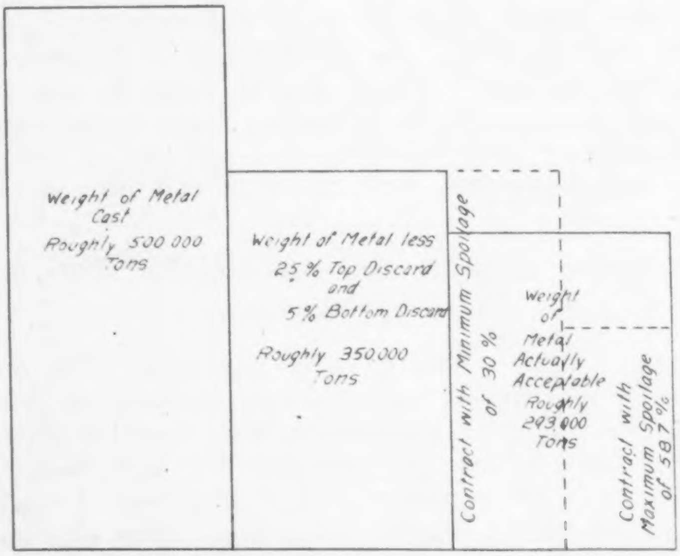


Fig. 2—Relation of Weight of Metal Acceptable to Weight of Metal Cast

on the curves found in Fig. 2—which presents a generalization of this matter, without wondering about the wisdom of making no more insistent attempts to produce steel free from piping and undue segregation.

When we realize that of these 500,000 tons of steel but approximately 293,000 tons were acceptable, and when we appreciate that of this 500,000 tons of steel nearly half or namely 207,000 tons was unusable as a first-class product and that most of it was used as remelting stock, and when we multiply these figures by six, seven or eight in order to convert them into our thirty and forty million tons, we cannot help but realize that one of the outstanding problems in the metallurgical field today of interest both to consumer and producer is the production of stock free from, or comparatively free from piping and undue segregation, without the exceedingly heavy losses set forth in these curves.

If one firm can make steel of such high quality as to require but 30 per cent total discard, if two others can approximate this record with a total spoilage of but 32 per cent, if a total of 22 firms out of 40 can make steel with a spoilage of less than 39 per cent, what is the trouble with the practice of the other 18 firms that they cannot make steel free from piping and undue segregation without a spoilage between 42 and 58.7 per cent? This question is not asked as a consumer. It is asked as one who believes that in the long run that firm or corporation which cuts its wastage to a minimum

is in a more advantageous position than that firm which tolerates sloppy practice.

It is furthermore appreciated that these spoilages are not the ones used in commercial practice. The average spoilages in the Pittsburgh district between the years 1902-1906 are given as 15.15 per cent. It is assumed that this is the average spoilage figure for today. It is my contention, however, that that firm which showed an average spoilage of 30 per cent is making a consistently better product--though today's spoilage may be but 15.15 per cent—than that firm which required a spoilage of 58.7 per cent in order to free its metal from piping, undue segregation and surface defects. It is also my feeling that that firm which showed the lowest discard with equal costs as to raw materials and freight, is making its product at a lower cost than any of the other plants, especially those that required a spoilage of over 42 per cent. This statement is made on the basis of the general observation that those plants with the best technical control, when the same is not carried to an extreme—and in none of the 40 plants listed is such the case—those with the lowest operating costs—conditions as to cost of raw materials and freight being the same—are those with the most carefully controlled practice

Mills Have Not Readily Adopted New Methods For Reducing Piping and Segregation

For some time I have wondered why our large mills did not receive more enthusiastically the various methods now available for reducing piping and undue segregation. There is no question with regard to their effectiveness.

At first glance many of us have assumed that any change which would result in a 10 per cent or more greater yield from a heat of steel would result in an increment equal to the weight in question times the selling price of the steel. Thus if the daily output of a firm were 5000 tons then a 10 per cent weight saving through the use of a hot-top or similar device would mean 500 tons greater output, which at an assumed average selling price of $24 per ton would be $12,000, or on a yearly basis there would result an assumed saving of 12,000 times 300 working days or $3,600,000.

In this connection we have utterly forgotten the cost of the refinement which must include the cost of the top, the additional labor involved, the cost of the additional buildings, building sites, trackage and other items. I have no figures on these phases, but they must be considerable, amounting well over a dollar a ton in the mills best situated for this refinement. In some mills, the expansion due to normal growth, accompanied by a resultant ground congestion, has been so great that it would not be practicable to consider the use of hot-tops. In other mills this condition does not exist and plants thus advantageously located should seriously consider their use.

A striking feature of adequate discard, however, is the relative cheapness with which it can be made. These facts are brought out in the curves showing the relation of spoilage to cost increase per ton of produced billets—Fig. 3. The figures are based on the average Pittsburgh price for 1902-1906 given in "Report of the Commissioner of Corporations on the Steel Industry," Part II, dated January 22, 1912.

The prices for this period have been chosen because they will represent approximate cost figures when freight rates have been dropped to a prewar basis; a drop we are all looking for and must receive before iron and steel prices can further decline. In fact, iron and steel would be found to be

selling at a lower figure today than at many of the prewar prices if the items due to freight were neglected.

With 15.15 per cent spoilage the cost of billets is given as $18.88. Were there no spoilage the billet cost would be $17.73 per ton and of this sum the cost of the metal in the ingot form would be $16.10 per ton and the cost of converting the ingot to the billet would be $1.61 per ton. Properly chargeable therefore, as increased costs in the production of a ton of billets with a spoil-

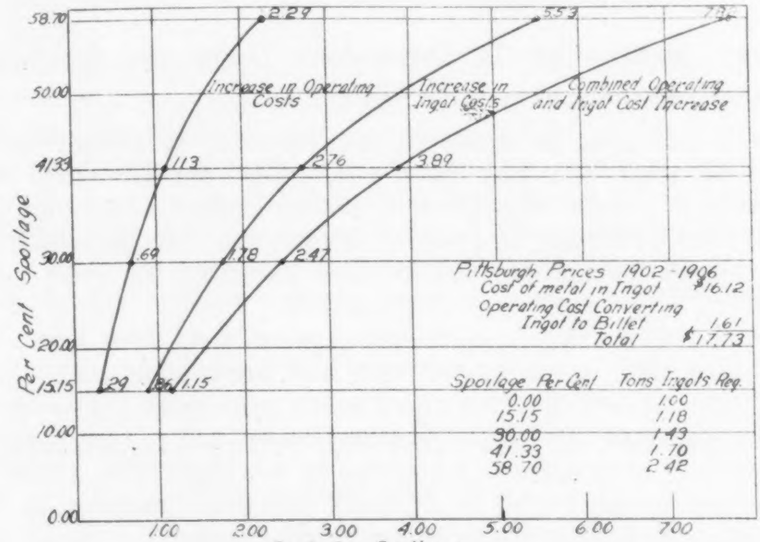


Fig. 3—Relation of Spoilage to Cost Increase Per Ton of Billets Produced

age of 15.15 per cent is 29 cents for operation and 86 cents for metal, resulting in a total cost increase of $1.15.

With a spoilage of 30 per cent the operating cost increase would be 69 cents and the metal cost increase $1.78, making a total increase of $2.47. With a spoilage of 41.33 per cent these cost increase figures become $1.13 and $2.76. A total of $3.89. With a spoilage of 58.7 per cent these figures rise to $2.29 and $5.53 resulting in a total cost increase of $7.82 per ton.

The ingot cost increase is not as striking as one might at first assume, because the actual metal loss in converting an ingot to a billet is but approximately 34 pounds. All of the remaining weight of the ingot not converted into acceptable billets is placed in a scrap class with a price value of $12.35 per ton. Thus the actual metal loss from this source is at the rate of $3.77 per ton of scrap produced.

Were it necessary for the trade to insist and the mills to produce, therefore, stock free from piping and segregation greater attention would be given to these cost figures than is the case today. Thus those firms which could keep their spoilage down to the lowest percentage, would have a distinct advantage, if the same were done at materially no increased cost, over those firms which ran into the higher spoilages.

Thus the production cost of a firm producing 1,000,000 tons of billets, with a spoilage of 58.7 per cent, would be $4,350,000, more than that of a firm with a spoilage of but 30 per cent. It is assumed that operating and raw material costs are the same. The spoilage percentages selected represent the highest and the lowest from the 40 firms to which reference has already been made. There were no outstanding refinements in the operating procedure

of any of these firms. None of them, to my knowledge, used hot-tops. None were particularly expert in the manufacture of shell stock at the time the contracts were let. The only explanation I can give for the variance in the practice is great attention to details. Details of refining practice, pouring temperature, pouring height, proper centering of the pouring stream, cleanliness of ladles and molds, proper time and temperature control for the heating of the ingots or blooms, and proper rolling practice involving proper maintenance of the rolls.

Manufacturer's Reputation Is Dependent Upon the Quality of Their Product

Good steel can only be made in the furnace; it cannot be made in a ladle in spite of what one may hear otherwise—nor can steel with proper surface be made in poorly aligned or imperfect rolls. Two years ago I was asked if alloy steel could not be rolled in a mill, the rolls in which were themselves ready for the scrap. My advice was to scrap the rolls and save the firm's reputation.

The day is not yet here when we require steel free from piping and segregation. However, is there one who will argue that such steel is undesirable? Is there one who prefers piped stock, and more especially segregated stock? Is not the trade going to demand more and more insistently stock free from defects? Are not those companies who carefully control the items leading to quality going to be in a vastly superior position to those firms that tolerate or inadequately check sloppy mill practice?

The whole problem is not an easy one. Yet for each individual firm so much is at stake, its reputation, the sale of its product, possibly its very existence, that it does seem that some of these matters should be given more careful attention than it has been my lot to observe is generally the case.

To some it may seem that the whole force of the preceding paragraphs has been nullified by the fact that certain uses of steel do not require perfect stock. It is quite agreed that there is no necessity for using a gold tack when an iron one will do as well. The trouble is, though, that those firms who base their emphasis on tonnage sell some of their stock for purposes which need careful inspection. In 1916 I saw piped shell steel discard sold for conversion into steering pins. In fairness to the steel company I believe they were uninformed with regard to the prospective use of their product. Nor do I, today, know of any automobile companies guilty of such negligence. Not only is proper discard necessary to insure freedom from piping, but also to insure freedom from segregation. In the case of segregated stock subjected to severe service such as in rails, the life of the product is much shorter, to say nothing of the hazard to life being greater, than in unsegregated stock. Stock which is to be machined should be segregated if one is to maintain good will in machine shops operating on a price basis. A bar of 0.72 per cent carbon steel mixed in with bars of 0.30 per cent carbon steel, both procured from the same ingot because of insufficient discard, can be of material weight in disrupting an organization. Items of this type have been altogether too little considered.

Primarily the procurements of piped and segregated steel lies with the purchaser. He can today, and could, even in the days of 1919 and 1920, purchase any grade of steel he desired. There were firms then and there are firms now who will state that they will furnish good steel though not inspected with sufficient thoroughness to insure freedom from piping and segre-

gation. Prices from mills of this type are usually as low, if not lower, than the prices from mills that more rigidly inspect their product. For many purposes steel of this grade is acceptable. For others it is not, although the price tempts the purchaser. Ultimate cost and essential reliability should be the criterion; not first- cost.

A forward step which is sincerely desired, however, is that every mill will make a thorough-going effort to improve the quality of its steel. Practice at our various mills is not uniform. The tabulations in Fig. I demonstrate that point.

When that day breaks; when all of our mills are making steel of such high quality that a spoilage of 30 per cent would insure complete freedom from piping and segregation, and a spoilage of 15.15 per cent would insure steel of an acceptable, though not of the best, quality, we will find both consumer and producer in a mutually happy frame of mind; the consumer because of the more uniform character of his purchase and the producer because of a material reduction in complaints and because of what I believe will actually be the case, a material reduction in his manufacturing costs.

The Use of Various Kinds of Light In Metallography

(*Continued from Page* 719)

It has been found that the aforesaid only holds true where the beam of light is relatively small in comparison with the cross section of the crystal. However, if this beam is large enough to fill the back glass of the objective, it is not possible to produce a totally dark field by a rotation of the analyzer, but the phenomenon just mentioned occurs wherein the field reverses color. In the case of Figs. 4 and 6, a smaller pencil of light was used, with the result that the field is more nearly totally dark.

Conclusion

These two cases, along with numerous others, lead to the conclusion that where the beam is relatively large, only a part of the center is darkened, and the remaining light comes in around the edges as a sort of leak, so to speak, thereby obliquely illuminating the sample. From all indications, then, it would appear that this is a method of obtaining micrographs at high magnification with oblique light.

In closing there is one more point for consideration, and that is, to what limits is it practical or necessary to magnify photomicrographs. The photomicrographs shown in Figs. 8 to 13, inclusive, are all of lamellar pearlite, with the exception of Fig. 9, which is a very low carbon steel showing ferrite, ferrite grain boundaries, and a central area of lamellar pearlite. The magnifications range from 1200 to 11,000 diameters, all taken with the same objective, but with different oculars and different camera bellows extension.

The photomicrographs speak for themselves and show of what value they are in the analysis of materials microscopically. The photomicrograph shown in Fig. 13 was taken at a magnification and direct projection of 11,000 diameters, the specimen being a steel showing a structure of lamellar pearlite. When the magnification of this photomicrograph was measured, one-hundredth of a millimeter nearly filled a 5 x 7 ground glass, the long way of the glass. The value of such a photomicrograph is patent.

Comment and Discussion

Papers and Articles Presented Before the Society and Published in Transactions Are Open to Comment and Criticism in This Column—Members Submitting Discussions Are Requested to Give Their Names and Addresses

Corrections Pertaining to Discussions Following Papers Presented at the Metallurgical Education Symposium, Detroit Convention

It is with regret that our attention has been directed to the fact that certain stenographic errors existed in the discussions following some of the papers presented at the Symposium on Metallurgical Education, Detroit convention, October, 1922, as published in the February issue of TRANSACTIONS.

In order, therefore, that any of the errors which exist may be corrected, we are reprinting several of these pages which have been reviewed by the respective authors. Our apologies for these errors are respectively extended to these gentlemen.

Pages 545-548—*February* 1923, TRANSACTIONS

Professor Knight's Contribution to the Symposium

In the school of mines at the Pennsylvania State college, we gave three curriculi; a curriculum for metallurgists, for mining engineers, and for mining geologists. The first two years is the same for all three curriculi. And we believe that there is an advantage in having the first two years the same, because, first, these years are devoted to such subjects as English, mathematics, physics, chemistry, and such fundamental subjects as are necessary as a foundation for the remaining portion of the curriculum, the last two years. And second, it gives a student a chance to study two years, and then decide what he would like to take up, whether he prefers metallurgy, mining geology, or mining engineering.

I might review briefly the last two years of our courses of metallurgy. The first semester in the junior year there are 2 credits required in physical chemistry, 2 in dynamo machinery, 1 in electrical engineering laboratory; 2 in applied mechanics; 3 in assaying; 5 credits in the principles of metallurgy, and one hour in coking. These involve laboratory as well as class room instruction. The second semester: Metallurgical analysis, 3 credits; power laboratory, 1; steam engines and boilers, 2; engineering materials, 2; testing materials, 1; metallurgy of copper, 3; metallurgy of iron and steel, 4; stresses in mine structures, and hydraulics. The senior year is devoted, the first semester to electro-metallurgy, 2 credits; electro-metallurgical laboratory, 3; principle of economics, 3 credits; economic geology, 3 credits; alloy and metallography, 4 credits; ore dressing and coal preparation, 3 credits.

The second semester of the senior year: Transportation problems; there is an option here between commerce—15, which is transportation problems, and economics—2, current economic problems or political science—13, political parties—3 credits; engineering law, which em-

bodies engineering contracts, 2 credits; metallurgy—74, advanced metallography, 3 credits; and the metallurgy of gold, silver, lead, zinc and minor metal 5½ credits; metallurgical thesis, 3 credits; and mining—78, which is the ore dressing laboratory, 1½ credits.

Now, in connection with that, I might say that an analysis of our entire curriculum shows the following results, and this is what I would like very much to have had in the form of a lantern slide for every one to see. As far as a broad general training is concerned, we try to give it. And as Mr. Knowlton was saying, any suggestions or criticisms I can obtain from anybody here, I would certainly be glad to receive. It would be impossible for you to see this on a small scale, but I would be very glad to show it to any one after the meeting. (Indicating course of study in small type). The title of this, in case you should want it is "distribution of subjects in courses in the school of mines, 1921-22, Pennsylvania State college." On this side I have the courses for the freshman, sophomore, junior and senior. Here is the semester; and above is the school in which the various subjects are taught. There is the engineering school, liberal arts, mines, natural science. Then here is a column entitled "common" and under that is "hygiene and physiology and military drill." I will summarize briefly what we have here in the metallurgical curriculum. In engineering work we have 20.3 per cent of their credits; in liberal arts, 26.68; in the school of mines, 34.32; in natural science, 13.64; in physical education, hygiene and so forth, 5.33; making 100 per cent in all.

One thing I would like to call attention to here, which is that there are only 13.64 points required in the natural science school. That is due largely to the fact that at Penn State, geology is taught in the school of mines rather than natural science which is done in a good many institutions. Likewise, mathematics is taught in the liberal arts which gives a rather high percentage, 26.68 for liberal arts, whereas it is very often included in the natural science group.

Now, I have detailed information concerning just what the various courses are during the different periods, that is, for the freshman, sophomore, junior and senior, for the metallurgist, mining geologist and mining engineers, in the table as it is worked out.

We believe in, as you will notice, 26.68 points of credit in liberal arts, and the fact I pointed out, there are the English requirements, and the requirements in economics and transportation problems, in giving as broad an education as possible. Our present curriculum is the result of a revision that has been made in the last three years. During the last three years we revised our metallurgical curriculum, and we did so by first writing to the alumni of Penn State, back as far as the graduates of 1896. We wrote to such men as Arthur G. McKee, H. M. Stuart, the superintendent of blast furnaces at Duquesne; and A. N. Neal, superintendent of the Duquesne Works, Carnegie Steel company and from then on down the rank, to the 1918 and 1919 graduates. We asked them to cooperate with us and to write in and tell us what our curriculum lacks, and what it has in it that we can eliminate. By doing that, we have the present curriculum as it is in the catalog.

I would like to call attention to something that perhaps most of you are familiar with, and that is Bulletin No. 150 of the Mining and Metallurgical Society of America; which is entitled "A Report of the Committee on Technical Education." It is by A. H. Rogers, chairman; L. C. Gratton, and A. H. Guest. They have there brought out a good many points. They

have pointed out the distribution of time on a percentage basis, devoted to different subjects in the different schools of the country. At the bottom of this, there is an average given, an average for all schools; and Penn State does not fall far from the average.

There was one thing that was mentioned in this report of the Mining and Metallurgical society, on page 183. I will just mention a word about it here. I will not take the time to read it, but I will give you the sum and substance of a part of that page. It states that the metallurgical or mining curriculum is outlined by the faculty of the mining school, and many of the subjects are taught in other schools, liberal arts, engineering and so forth; and as I have pointed out, they are very often taught with the viewpoint of making specialists in English, or specialists in economics and so on, out of the different men, rather than with the viewpoint that they are to become mining and metallurgical engineers.

We try to get around that difficulty by co-operating with the different departments of the college. We have been co-operating particularly with the chemistry department in the last few years, which was not the case several years ago. The way this is handled is that the chemistry department expects us to give a course in metallography for the special benefit of the chemist and we tell them that we will gladly comply with their request and will be glad to give a course in metallography; providing they will specify what they want taught. In the meantime we expect them to return the favor, and reciprocate by giving us courses in chemistry that will be particularly suitable to the metallurgists.

Another thing I would like to mention is that we are strongly in favor of the senior members of the teaching staff, teaching laboratory work. It is quite common in institutions for the heads of departments and men higher up on the staff to do the lecturing and conduct the recitation work, and allow student assistants and men of inferior rank to take care of the laboratory instruction. We believe that the men higher up should give instruction in the laboratory, because they are in a position to inspire the young men and work up the enthusiasm that otherwise would not be obtained. And, in a metallurgical course anyway, we believe that the real instruction comes in the laboratory, where you are really doing things.

We also believe in a thesis. We believe every student should be required to work out some problem, and submit a satisfactory thesis before graduation. We think this, because it gives the student an opportunity to show his initiative, and to show what he can do in the way of handling problems of his own. And it is a good experience for him to go after some particular problem, the like of which he may run onto, and no doubt will, when he gets out, and he then has had some experience in solving such problems. The second reason we believe this is a good thing is because it gives the instructional staff an opportunity to pick out the students who will likely make good research men. And as we know from the various research meetings which have been held in the last few years, research men are hard to find, and they are scarce.

I might add, that we have metallurgical inspection trips specified in our curriculum. The second semester of the junior year is given a four hour course in the metallurgy of iron and steel. At the close of the semester, the students are taken on a two weeks iron and steel inspection trip. During this trip all phases of ferrous metallurgy are carefully

studied. Each student is required to hand in a complete report of all operations studied.

During the second semester of the senior year, a course in nonferrous metallurgy is given. At the Easter recess period a two weeks nonferrous inspection trip is taken. Both the ferrous and nonferrous trips are planned by an instructor who accompanies the students and is in charge of the work at all times, and explains the operations observed.

The Mining society, which is affiliated with the American Institute of Mining and Metallurgical Engineers is also an important organization at Penn State. The society is composed of the faculty and students of the mining school. Meetings are frequently held at which times prominent mining and metallurgical men are secured as speakers. This brings the student in contact with practical operating men.

If a student wishes to spend five years, he is given an opportunity to study for the degree of Master of Science which may be obtained in one year after the degree of B. S. in metallurgy has been obtained provided the required amount of work is satisfactorily performed.

The degree of Metallurgical Engineer is given to four year graduates of Penn State after they have been in responsible work for at least three years and have submitted a satisfactory thesis.

Discussion of Professor Knight's Contribution

Mr. Thum: I would like to ask what was eliminated from your curriculum as a result of the questionnaire.

Prof. Knight: I am sorry I do not have all of the old catalogs which will gave this.

Mr. Thum: In general, what did you eliminate as being nonessential and what did your graduates regard as being essential?

Prof. Knight: There was one subject that we did not eliminate although there was considerable debate upon the matter, and that was the course in "stresses in mine structures." Most of the men seemed to be of the opinion that this course should not be eliminated. So that, instead of eliminating the course we made an optional between stresses in mine structures, hydraulics-1 and laboratory-3. This is one of the things that we made flexible. We elimінted 3.5 credits in surveying and 3 credits 3 credits in mining.

Another thing that we eliminated was a course in geology. The metallurgists were having a little too much geology, and we thought we could eliminate geology and put in advance metallography. Now, they have eight hours laboratory work in the second semester. If I had an old catalog, I could give you everything and would be glad to; if you are particularly interested, I can look that up and give you the whole thing in detail. Are there any other questions?

Mr. Thum: May I ask if there was anything added besides an advanced course in metallography, and if the work in economics and such allied subjects were also partly due to this questionnaire?

Prof. Knight: The work in economics I believe has been in the curriculum for a number of years, but was increased because of opinions expressed in answer to our questionnaire.

Pages 560-566—*February* 1923, TRANSACTIONS

Prof. Goodale (chairman): Is there any discussion on this paper?

Mr. Thum: Mr. Chairman, I have listened with a great deal of interest to the various addresses this afternoon. It seems to me that the tendency of modern engineering education is toward the longer course; five years and even six. Personally, I feel that such a step would be a mistake, principally because it would limit the number of students who could partake of the educational advantages of this country. It is hard enough for a great many of our good students to go for four years, but it will be very much harder to go five years, and I think that a six year course is practically out of the question.

Of course all education is good. I believe none of us would deny that a man who is educated in the liberal arts would make a better engineer than a man who merely had a high school education. I am quite sure that he would make a better engineer; in addition to that, he would make a better citizen.

Now, it might be argued that if the engineering schools are to teach engineering, they would do well to stick to engineering. By that, I do not mean of course that absolutely no attention be given to English or public speaking, but I do think that rather than extend the course of the present four years to five or six years, in order to take up humanities, it would be very much better to examine carefully the present curriculum, and see whether some of the things which are given at present could not be well substituted by other courses.

I have traveled around more or less in the last four years and visited many of our prominent technical schools and before that time I had the honor to be a member of the faculty of the University of Cincinnati. My present information is to the effect that most of the metallurgical courses at present offered in this country are hybrids; they are merely slight adaptations of mining engineering. Of course, there is an historical basis for that.

When I was a boy, heat treatment was practically unknown. The modern large smelter and manufacturing plant was unknown. Most of the ore smelting was done close by the mine. Things have changed in 30 years; and perhaps in 30 more years the universities will come to the conclusion that they had better do something about it. I speak advisedly because, having been a member of a university faculty, and of a school not so backward at that, I would like to stake the ordinary university against anything in this world when it comes to sheer inertia. They will get around to it after while, but it seems it is a long time coming.

Again reverting to the fact that metallurgical engineering is more or less the same as mining engineering, I would like to ask why the metallurgist should be asked to take mining surveying, for instance or mining engineering. The metallurgist is not particularly interested in the long wall versus the pillar and room method of coal mining, or the square-set methods they use for timbering stopes, or the steam shovel methods used in the iron country, and yet he in a great many cases has to take that as a prerequisite for his graduation. It seems to me that since there is a great demand for the humanities, it would be very well, indeed, to go after some of these so-called metallurgical subjects with a sharp broad-axe, and cut out some of these things which they have had for the

last few years, and which have not the remotest connection to the technical end of metallurgy as we understand it at the present time.

Of course, in order to revise and re-vamp a course of study, you would have to define metallurgy. That would be a difficult thing to do. But, if you agree with me that it involves the preparation of a metal from its ore, the preparation of alloys from the metals and the properties and heat treatment of these metals and alloys—from such a definition of that sort, or a more perfect one, it would be comparatively easy to get a curriculum which would be restricted to that field more or less closely, and would devote any extra time to such things as English, public speaking, history, economics if you will and some of the other things in literature and art which are supposed to make an engineer a good citizen.

Now, it has been brought out, and I think very well, that the fundamentals should be taught rather than the specialties. No university can turn out a specialist. In the first place, they have not the equipment; in the second place they have not the teachers. The best they can do is to ground a man in the fundamentals. And I think that metallurgy could be taught very well from that standpoint. In the preparation of the metal from its ore, you have several fundamental operations, roasting, smelting and refining. The fundamentals of roasting are much the same whether you are roasting the ore and producing sulphuric acid as a by-product, or whether you are roasting a relatively small amount of sulphur from an iron ore. There is a great deal in common in the blowing of bessemer steel, copper matte and open hearth refining of pig iron. And so when the students get over into the alloys, they should have physical chemistry and physical metallurgy as fundamentals. In that connection a great deal could be done for our young students and as far as I know, it is seldom being done in this country, in teaching them the practical end of alloying; for example, how to make a brass casting that does not look like a sponge. Then, going on further they would enter the broad fields of heat treatment, hardening, carburization and what not, which applies not only to steel, but to a great part of aluminum and copper alloys as well. It would always be well to teach these things from their broad aspects, to show the pupils the underlying generalities, rather than to lose them in a wilderness of facts.

Given, finally, a modern curriculum on metallurgy, you come right back to one of the great questions. It is not *how* you teach, or *why* you teach, but it is the *teacher himself* that counts for the most. I personally am a great believer in the idea that the student gets the most value out of university training from his instructors and from his fellow students. By all odds, that was the greatest thing in my own university life; and observations of other chaps since that time has only confirmed that belief. The prime thing about university life to make a good citizen, to make a good engineer, is to give him the right kind of instructors, men he can look up to; and then give him the right kind of associates, the right kind of surroundings, and great things will result.

Now, unfortunately,—I rather venture on this with some temerity, in view of many good friends in the teaching profession here—unfortunately, we haven't as yet the right kind of men teaching metallurgy. I feel that we will not get those men until some of the big business men in the steel, copper and the other metallurgical industries,

realize that in view of the importance of metallurgy, the attention and financial support which they are giving to metallurgical engineering is shameful. There is no other word for it. We have tremendous foundations and endowments in medicine and law, and whatnot; and yet here is a fundamental industry of our country, which enables us to produce more metals and metal products than any other country in the world, and yet we have no organized effort in the industry for the teaching of the men who are to carry that work forward. Until the industry realizes that fact, until the university can properly endow the laboratories and properly endow the chairs, so that they can go out into the industry and compete for the right metallurgists and put them in the right place, I am afraid metallurgical education in this country is going to be backward.

Prof. Boylston: Mr. Chairman, there is one remark I would like to make here. Mr. Thum spoke about the course in mine surveying that we give the metallurgist. He mentioned that specifically so I think I ought to say something about it. I believe that is one of the courses that does more to humanize the student than perhaps any other course in our school. They go down to camp for about four weeks, after proper class-room instruction, so that they may know how to use the instruments, they climb around in the muck and they live out of doors for a month, in association with their companions and with their instructors, and they have a nice rough time of it, and they learn a good deal more than mine surveying as it is mapped out on paper. I think that is a real humanizing course; that is so in our school anyway.

Prof. Demorest: There is one thing that I would like to add. One of our number just touched upon the tendency everywhere for engineering schools to require some practical experience from the men before they graduate. In our course in metallurgy, at Ohio State university, a man cannot get his degree until he has had one whole summer, at least in practical work in this line. Then he has to come back, with a properly certified letter concerning his work from his employer; and the teacher checks up in other ways on that man. In addition to that, we have inspection trips, as Prof. Boylston's slide shows you. So that there is a good deal of the practical touch in the course,—as much as can be made possible.

Prof. Upthegrove: While I agree with Mr. Thum in many ways, I would like to point out that our work at the University of Michigan is not the outgrowth of a mining engineering course, but of chemical engineering. We have one mining engineer of whom we are exceedingly proud, Mr. Brush of Cleveland, who was granted the degree of Mining Engineer by the University of Michigan. (I believe I am correct in the statement that Mr. Brush received the degree of Mining Engineer.)

Our course does not carry many of the subjects to which Mr. Thum referred, but it carries certain fundamental chemical engineering courses. We believe a metallurgist should have a fundamental training in chemical engineering. Our course has not developed as far in metallurgical work as we should like. We should like to have it include certain things along the lines on which Mr. Boylston spoke. Our metallurgical work starts in on the extractive basis, and follows with a certain amount of work on fabrication. We are attempting, although not to any great

extent, but just starting in along another line that Mr. Thum mentions, to show a man how to produce what you would call a "finished casting." That is a little in the distance as yet, but it is a line along which we are working at the University of Michigan. The nature of our course is probably due to the fact that we were not connected with a mining engineering course to begin with, but that the metallurgical work is the outgrowth of chemical engineering.

Prof. Boylston: I would like to add that in Cleveland we teach our boys in the technical high schools how to mold and do certain other foundry operations. We do not believe that the college grade of school should teach trades or the art of any particular metallurgical process from the point of view of the art itself. We also are trying to teach fundamentals. We may not have the same idea as some others as to what the fundamentals consist of but we are trying to teach fundamentals, not art. That seems to be a necessity. I do not know where you can get the principles outside of a college course, except in the school of bitter experience. Taken by and large, our courses are planned from the standpoint of principles rather than practice.

Mr. Thum: Just a word more. I would be extremely sorry if any of the remarks I have made were taken in a purely personal way by any of the men here either against them or their institutions. I tried to make them general; and the general ideas, which I so very poorly expressed, were that we yet have to approach metallurgical education as a unit itself and not as a hybrid; and second, the metallurgical industry is not supporting metallurgical education as it should.

Mr. McKnight: Speaking entirely from my own very brief experience, I would say that the education of the metallurgist could be divided up to include four phases, that of the fundamentals (which have been spoken about) breadth, balance and co-ordination.

It is necessary to dwell long on fundamentals. It is almost axiomatic that an engineer cannot go into the higher studies unless he understands elementary chemistry and physics and mathematics.

As far as breadth is concerned, I think that the subject of specialization can be carried too far. If a man could look ahead 50 years and see that all of that time he is going to be engaged in the production of steel by the open-hearth process, eventually arriving at the position of open-hearth superintendent, at which job he would stay, it would be very easy to teach that man how to produce steel by the open-hearth process; and you could then specialize. But, when a man leaves college, he does not know whether he is going to be a heat treater, an open-hearth superintendent, or in any other particular kind of work. He may change into five or six different lines of work. Therefore, I think it is very proper that the colleges should keep their courses as broad as possible. It should not be carried to the extreme. I was thinking of a moment ago where one of the colleges had a man who was pretty good in football. He flunked the course in ancient history, and the professor tried to coach him through that course, but he seemed to be bent on fouling it, so that finally the professor gave it up in despair. The man had to play the next day, so the professor said "answer one question, and I will let you out." He asked him, "who dragged whom around the walls of what, how many times, and why?" And he could not answer the question.

The next point is balance. That is best illustrated in my opinion by a brother of mine who was graduated from a well known eastern university, intending to go into the steel business. In his senior year, he studied Italian literature, Spanish history, political economy, accounting, and field artillery. I think that is what you would call a case of very poor balance in a man's education. It seems to me that he had a very poor balance between what has been termed here the humanizing elements of the course, and the more technical elements. There is a dividing line.

The fourth point—that of co-ordination—is mentioned because I think there are so many students who study metallurgy and get out in the world as metallurgists with unco-ordinated facts. As an example, take the boy who studies the metallurgy of steel at one time in his college course, mechanics of materials at another and heat treatment and metallography at others. He must learn from practical experience the relation of these subjects. To remedy this situation, a student might be given a piece of steel of standard analysis and be required to analyze it, to pull a test piece, to examine it under the microscope and to heat treat it. If this were consistently done, the facts learned would be of real value to the student.

Prof. Boylston: Mr. Chairman, may I say that our so-called thesis work is planned with the idea of co-ordinating all of the previous courses.

Of course, we do not have as much time to do it as we would like to, but our men have five afternoons a week, of about three hours each, and as much extra time as they can cram in for half a year with just that purpose in mind.

I would rather they would learn how to do that, rather than get any actual results, that is, results of value for publication, or anything of that sort.

Prof. Demorest: I might add one thing along that line, and I think it is going to be very effective in our course in metallurgy, and that is running throughout the last two quarters of the senior year we have a course called "metallurgical investigations," in which the class is divided up into perhaps three sections and maybe four, depending upon the type of men we have; and each section then takes a subject, and under the direction of the instructor carries out a complete line of investigation. That is entirely different from his thesis which he has to carry on his own accord. Then the other section of the class carries out an investigation under the direct supervision of the instructors. That has been found very valuable and particularly effective in other work, and we have taken it over in metallurgy. It may be useful to others.

Mr. Wood: There is one point about the fifth year which I wish to mention. It has been said that it would not be possible in many cases to send the boy to school five years; that it is hard enough to send him for four years. Actually, this does not present much difficulty because in a great many cases there are assistantships and fellowships open to students that make possible the fifth year at college. In many cases one finds that this happens: A man will graduate, go out and take a position. After a short time, problems will come up which show him that a fifth year at college would be very useful and he makes arrangements to come back and stay the fifth year. Once in a while the plant

for which he is working will give him financial assistance. I believe there is a distinct tendency toward a five year course and that the financial question is not difficult to solve.

Prof. Boylston: Mr. Chairman, may I say just a word on that? It seems to me it makes a difference in the case of the fifth year whether you are going to prescribe it as a part of the required course, or whether you make the fifth year optional with those who can afford to take it. My choice would be to have an optional fifth year, lay out an optional course for the students, and allow those who have the additional time and means to take it. In most colleges it is handled through the graduate school and we are doing this now. This is quite a different matter than to have a five year required course as some schools do.

Prof. Goodale (chairman): I might say, from my own experience, that our curriculum, in both the mining and metallurgical engineering courses, is under almost constant revision—I have sometimes thought too much so—because we hardly get the curriculum on one basis in working order before we get a suggestion from some source or the other, where they think we can make it better and changes are made. In that way we attempt to make the curriculum as effective as we can, so that the men we turn out will make good in the industry. We are very much on our toes toward that end, and we are in close touch with the great steel industry in Pittsburgh and in close touch with our alumni, so many of them finding work nearby, that I feel we are in an exceptionally favorable situation to learn what is needed.

I am sure that we can go on almost indefinitely and have others outline their experiences and their ideas. I feel that I owe an apology to the speakers who have favored us so far. Most chairmen of meetings will say more in words of appreciation of the speakers than I have; but I have not done so merely to save time on the program. It seems to me that each man has brought up a great deal that is well worthy of the attention of us all.

We have a short written contribution from Huge P. Tiemann of the Carnegie Steel company and another one from B. H. DeLong, of the Carpenter Steel Co.

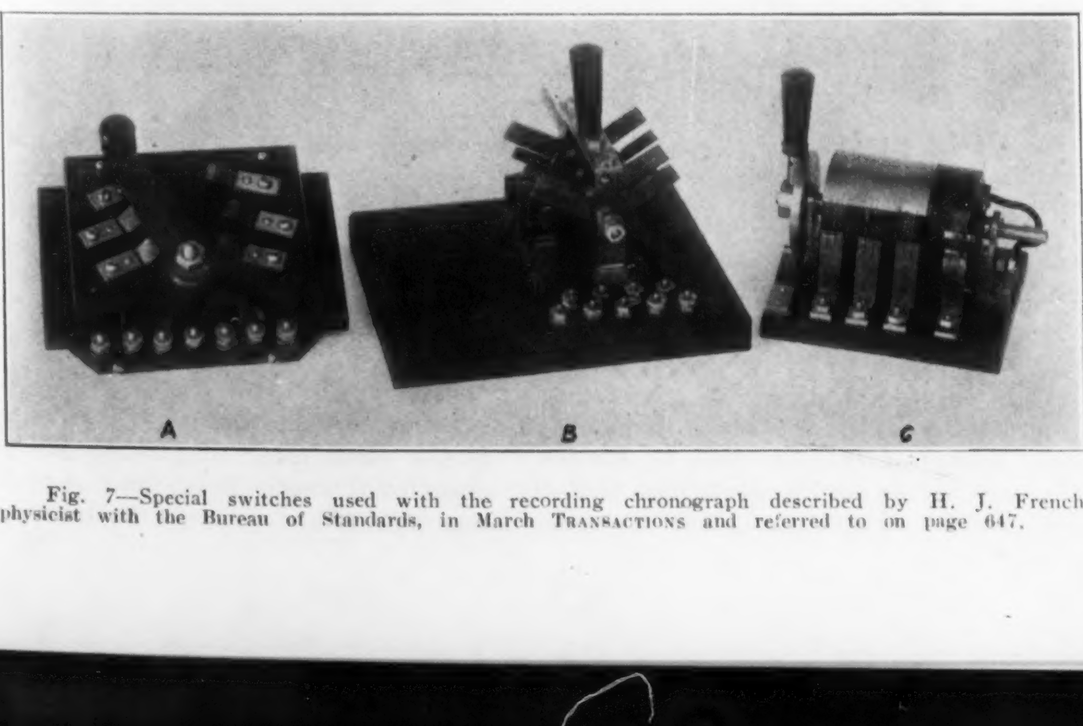


Fig. 7—Special switches used with the recording chronograph described by H. J. French, physicist with the Bureau of Standards, in March TRANSACTIONS and referred to on page 647.

The Question Box

A Column Devoted to the Asking, Answering and Discussing of Practical Questions in Heat Treatment—Members Submitting Answers and Discussions Are Requested to Refer to Serial Numbers of Questions.

NEW QUESTIONS

QUESTION NO. 76. *Why are cold drawn carbon and high-speed steels sometimes supplied with a copper coating? Does this coating affect the steel in any way, or is it merely a lubricating agent in the drawing process? Is it necessary or desirable to remove the coating before hardening?*

QUESTION NO. 77. *What is meant by the terms, elastic limit, yield point and ultimate load?*

ANSWERS TO OLD QUESTIONS

QUESTION NO. 27. *What is the function of the high phosphorus and the high sulphur content in the so-called automatic screw stock steel?*

QUESTION NO. 59. *Is a sulphur content of 0.067 per cent detrimental to the proper carburizing of a low carbon steel having a low manganese and phosphorus content?*

QUESTION NO. 64. *To what extent can the deep etching of specimens of steel be applied to routine examination of incoming material?*

QUESTION NO. 66. *What method and procedure is used in brazing stellite to carbon steel?*

ANSWER. The method and procedure in welding or brazing stellite to carbon steel is covered rather fully on pages 49 to 52 of the Haynes Stellite Company's publication, "Stellite Reference Library," Volume 9.

QUESTION NO. 67. *What is the reason for the fact that a piece of steel quenched in brine will be harder than the same piece of steel would be if quenched in water, providing that the quenching temperatures and quenching medium temperatures are the same in each case?*

QUESTION NO. 68. What is the correct temperature of heating for forging a .40-.50 per cent carbon steel into automobile crankshafts?

ANSWER. By Harold F. Wood, metallurgist with the Ingalls-Shepard Division of the Wyman-Gordon Co., Harvey, Ill.

It has been our experience that the proper forging temperature for forging .40 to .50 percent carbon steel for automobile crank shafts is from 2000 to 2100 degrees Fahr. We find that on most heats of steel this temperature can be increased to 2200 degrees Fahr., but in no case must it be allowed to exceed 2200 degrees Fahr. The safe working temperature is to be at all times kept under 2100 degrees Fahr. We have made hundreds of tests and are thoroughly satisfied that these temperatures are correct.

QUESTION NO. 69. Is sulphur up to .10 per cent detrimental to the quality and physical properties of an automotive steel?

QUESTION NO. 70. Is it possible to have a specimen of steel in such a condition that it will show in any one field observed under a microscope at 100 diameters magnification, ferrite, pearlite, sorbite, troostite and cementite?

ANSWER. By H. M. Boylston, professor of metallurgy, Case School of Applied Science, Cleveland, Ohio.

I have never observed in a single specimen the combination of metallographic constituents mentioned in the above question, although I suppose it might be possible to obtain it by quenching in water while the steel was

passing through the critical range, a steel let us say with 1 percent carbon which had been previously annealed to produce spheroidized cementite on a ferrite back ground.

A number of times I have produced a combination of pearlite, sorbite, troostite and martensite in the same specimen, by quenching an .80 or 1.10

per cent carbon steel while it was passing through the $Ac_{3.2.1}$ transformation the steel having previously been in a pearlitic condition.

The accompanying photomicrograph shows a combination of four constituents taken from a steel containing about .80 percent carbon and magnified 100 diameters. The white constituent is martensite, the darkest constiuent troostite, certain half-tone regions sorbite and the light gray regions pearlite. The pearlite and sorbite merge into each other but there is generally a distinct line of demarkation between the troostite and sorbite on the one hand and troostite and martensite on the other.

QUESTION NO. 71. How do the physical properties compare between a 0.35-0.45 per cent carbon acid open-hearth steel and an alloy steel of either 3.5 per cent nickel or 1.5 per cent nickel and 0.50 per cent chromium neither heat treated?

QUESTION NO. 72. What elements are conducive to good electric butt-welding of steels?.

QUESTION NO 73. Does electric butt-welding destroy the physical properties developed in a steel which has been heat treated prior to the welding operation?

QUESTION NO. 74. Why shouldn't a bar of steel rolled from a locomotive axle be better than one rolled direct from the billet made from the original ingot?

QUESTION NO. 75. How much would the cold drawing of any steel affect its hardness when only one or two, light passes are given for the purpose of sizing only?

ANSWER. A piece of 1-inch round 1.00 per cent carbon tool steel drawn with a 0.028 to 0.031-inch reduction will show 8 to 12 points higher Brinell number than the annealed section from which it is made. It is impossible to lay down a definite rule covering all sizes, grades and percentage of reduction.

A small section of chrome-nickel steel, annealed, showed a Brinell number of 121 and the same section after a 1/32-inch reduction showed a Brinell number of 156.

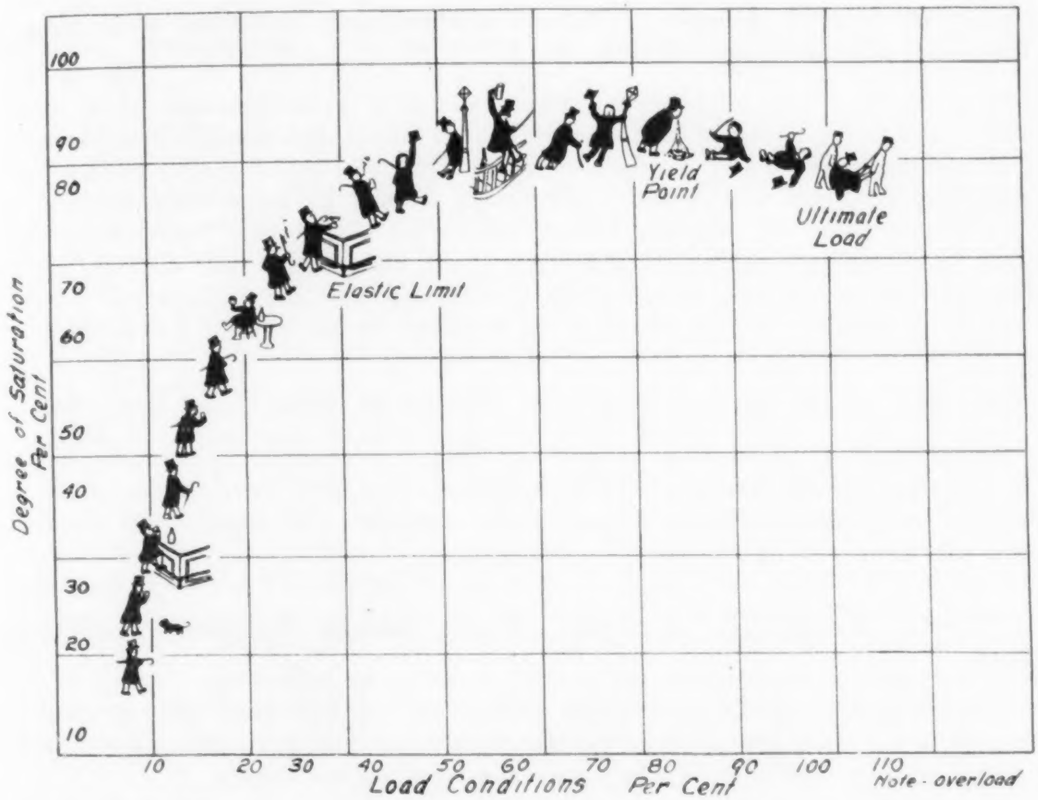
A piece of high-speed steel 0.768 × 0.383 inches, annealed, showed a Brinell number of 207, and the same section after 0.012-inch reduction showed a Brinell number of 212.

QUESTION NO. 77. What is meant by the terms, elastic limit, yield point and ultimate load?

ANSWER. The accompanying chart undoubtedly defines these terms

more clearly than could mere words. Of course there are other definitions which from a technical view point would be quite different, however, this is someone's visual or graphic interpretation.

As the author of this chart is unknown to us we regret that we cannot



give him the proper credit. Nevertheless, full credit is acknowledged to him to whom credit is due. Perhaps the author will be just as well satisfied that his name does not appear in print.

Reviews of Recent Patents

1,434,395. Electric Furnace. William Meinersmann, Elizabeth, N. J., assignor to Metal and Thermit Corp., Chrome, N. J.

This patent covers an electric furnace which is a combination of a roof, a hearth, a means for charging said furnace with a metal and means for withdrawing said metal and slag. There are one or more fixed electrodes associated with said furnace, one or more moving metal electrodes formed of compressed scrap metal and associated with said furnace. There are provided electrical connecting means between said moving electrodes and said fixed electrodes; this said connecting means forming the secondary circuit of the transformer and in addition a means for supplying an alternating current to the primary circuit of said transformer.

1,434,484. Process of Producing Iron. Donald M. Crist, Santa Cruz, Cal.

The process of producing iron from iron oxide which comprises heating the oxide in a closed retort to a temperature sufficiently high to dissociate the oxide, removing air and liberated oxygen from contact with the heated mass and cooling the mass out of contact with oxygen.

1,435,294. Manufacture of Steel. Robert Abbott Hadfield, Westminster, England.

Describes a steel alloy containing from about 2 per cent and upwards of manganese, from about 0.7 per cent up to about 2 per cent of carbon, a substantial amount of copper, and from 0.1 per cent and upwards of silicon.

1,435,304. Reverberatory Furnace. Archie Noel Jette, Anaconda, Mont.

This patent covers a furnace of the type described; the combination with the roof, a feed pipe extending therethrough and a solid metallic body containing a cooling coil surrounding the pipe.

1,435,742. Production of Refractory Metal Alloys. Byramji D. Saklatwalla and Arthur N. Anderson, Clarton, Pa., assignors to Vanadium Corp. of America, Bridgeville, Pa.

This patent describes a method which consists of feeding a mixture containing a vanadium-bearing material, a fluxing material, and carbonaceous material directly into the high temperature reaction zone of an electric smelting furnace.

1,435,812. Electric Spot-Welding Machine. F. M. Cushing and W. L. B. Cushing, Los Angeles, Calif.

A spot welding apparatus comprising a frame, chambers carried upon the frame and having offset portions extending into juxtaposition. A means to produce a circulation of a cooling medium within the chambers in contact with the cooling medium, and electrodes carried by the holders at points adjacent to the offsets of the chambers are described.

1,435.840. Manufacture of Steel. Robert Abbott Hadfield, Westminster, England.

Describes a manganese steel with about 1 to 4 per cent of copper.

1,435,991. Combination Gas and Oil Burner. W. W. Stevenson and O. H. Bathgate, Wilkinsburg, Pa., assignors to Anthony Company, Long Island City, N. Y.

A fuel burner having a liquid fuel duct within the burner, a spray plug at the outlet end of the said fuel duct, a gas chamber surrounding the said duct, and a means to discharge either liquid fuel or gas at the outlet end of the burner. In addition it has an air supply connection to the burner, an adjustable annular air passage at the outlet end of the burner, with the said passage being so shaped and located as to create a partial vacuum directly beyond the gas chamber while air is being forced through the said air passage. The outlets of the said air passage and the said gas chamber are located at some distance beyond the spray plug.

1,436,497. Electrode Furnace. J. H. Gray, N. Y. C.

This patent describes a combination with a tilting electric furnace of an electrode adjusting mechanism for said furnace with said mechanism comprising a motor mounted independently of the furnace and a flexible connection extending from said motor to the electrode. One part of the said connection extends from the motor to a member mounted on the furnace and engaging said member at a point which is substantially unchanged when the furnace is tilted and another part of the said connection extending from said point of engagement to the electrode, whereby the latter is held in substantially the same position with reference to the furnace when the furnace is tilted as when it is upright.

1,437,273. Manufacture of Ferrous Alloys. H. A. Skelley and A. B. Smith, Battersea, London, England, assignors to Continuous Reaction Co., Ltd., London, England.

This patent covers the manufacture of an alloy, containing iron and chromuim, by the silico-thermic reduction of iron oxide and chromiferous material in the presence of an oxidizing agent containing nitrogen.

1,437,405. Method and Means of Treating Molten Metal. F. L. Driver, Jr., Newark, N. J., assignor to Driver-Harris Co., Harrison, N. J.

A process of treating molten alloys adapted to be cleansed by magnesium, the improvement which consists in alloying magnesium with a heavier metal, the magnesium being approximately 50 per cent of the resultant product, and combining the resultant product with the molten alloy.

1,437,584. Refractory Material for High-Temperature Apparatus. H. B. Clapp, Battersea Park Rd., London, England, assignor to Ferolite Limited, London, England.

A refractory material for high temperature apparatus comprising a mixture of chromite and ferro-silicon reduced to small particles and mixed with a binding agent.

1,438,342. Reverberatory Furnace. W. F. Sklenar, London, England.

This patent covers a reverberatory melting furnace comprising a metal casing, a frame supporting said casing, and a lining of fire bricks arranged within said casing to form (1) a working bed with vaulted roof constituting a work chamber (2) an enclosed combustion chamber or fire place (3) a fire bridge (4) an up take and metal feeding hopper at the opposite end to the fire place, and (5) a restricted passage forming a communication between said hopper and working chamber. An inlet for compressed air opening into the combustion chamber beneath the fire bars of the grate, charging holes in the roof for fuel and metal as well as inspection and tapping holes in the side wall of the furnace are provided in this patent.

1,438,381. Electric Reverberatory Furnace. R. M. Keeney, Denver, Col.

This patent describes an electric smelting furnace comprising a smelting chamber, a settling chamber, and a passage narrower than the first-mentioned chamber, by which melted matter and gases of combustion produced in the smelting chamber may freely enter the settling chamber. Electric heating means establishing a determinate melting zone on the floor of the smelting chamber, in line with said passage, and a means for feeding material laterally into said zone are provided. The smelting chamber has a flue opening for the escape of gases of combustion and an opening for the outflow of melted matter below the upper level of said passage.

1,439,409. Tilting Furnace. J. A. Gaskill, Cleveland, O.

This patent describes a tilting furnace having in combination a melting chamber, an annular chamber for hot air encircling the melting chamber, and trunnions upon which said annular air chamber and melting chamber are pivotally supported. The supports for said trunnions and burners in said trunnions discharge tangentially to the walls of said melting chamber. Each burner comprises an elongated commingling tube open at its inner end, and a nozzle for fuel oil spaced from the inner end of said commingling tube, and a passage for air under pressure in each trunnion. Each of these passages communicates with said annular air chamber and the passages lead from said annular air chamber to said commingling tubes in the trunnions. The air supply pipes communicate with the air passages in the trunnions and the fuel oil supply pipes enter the annular air chamber through the trunnions and traverse the annular air chamber. In addition to traversing the air passages leading to the commingling tubes, the oil pipes communicate with the nozzles in the commingling tubes.

1,439,410. Refractory Material And Furnace Wall Built Thereof. J. H. Gray, New York City.

This patent covers a furnace wall comprising a body of carbonaceous material and an inside exposed facing of another refractory material which has a higher resistance to oxidation.

In addition this patent covers a brick for building furnaces comprising a body of carbonaceous material and a face of another refractory material which has a higher resistance to oxidation.

1,439,939. Low-Percentage Manganese Steel. F. M. Blake, Chicago Heights, Ill., assignor to American Manganese Steel Co., Chicago, Ill.

A commercial steel containing manganese and carbon in the proportions of about 4.25 per cent manganese and 0.42 per cent of carbon.

Abstracts of Technical Articles

Brief Reviews of Publications of Interest to Metallurgists and Steel Treaters

SERVICE FOR MEMBERS

The Library Bureau of the American Society for Steel Treating is operated to give to the members quickly, reliably and at the minimum expense the following service:

1. A complete copy of the magazine article referred to in any periodical you may be reading.
2. A translation of foreign articles that would help you with your work.
3. A list of references to books and articles on any metallurgical subject.
4. Informing the members of new articles of interest to them as an engineer.

The Library Bureau makes the entire field of literature available to every member, distance is eliminated, for it will copy the desired information and send it to you. It also helps the busy man by supplying information without any expenditure of his time. The charge for this personal work is merely its cost.

The Library Service does not obtain any profit from the work, but does this to make the information contained in the large libraries with which it has connection available to every member. The rates are as follows:

Photo Print Copies of articles, drawings, etc., 25c per 10 x 14-inch sheets.

Searches, abstracts, etc., $2.00 an hour.

Translations, $6.00 per thousand words for French of German; $7.50 and upward for other languages.

Reference card service, giving reference to current magazine articles, $10.00 a year in advance, and 5c for each card mailed.

Members desiring to avail themselves of this service should address Library Bureau, American Society for Steel Treating, 4600 Prospect Ave., Cleveland, Ohio.

THE CHARACTERISTIC CURVES OF A NICKEL STEEL AND A CHROME STEEL. By H. Jungbluth, in *Stahl and Eisen,* Vol. 42, page 1392, 1922.

The hardness obtained in a nickel or chrome steel depends on the temperature of quenching and the rate of quenching. Curves of the maximum hardness which can only be obtained by certain combinations of quenching temperature and rate as shown when the steel is quenched from a higher temperature it is softer because of the presence of austenite; if from a lower temperature it is softer because of pearlite formation. For every steel a set of curves of equal hardness may be drawn with rate of cooling and quenching temperature as co-ordinates. These are the so-called characteristic curves for the steel. They are given for a steel of 0.5 per cent C, 5.0 per cent Ni and for a steel of 1.6 per cent C., 1.6 per cent Cr.

THE FLOW OF METAL DURING FORGING. By H. F. Massey, in *Forging and Heat Treating,* February, 1923, page 122.

This is the second part of a paper presented at a session of the Manchester Association of Engineers, Manchester, Eng., dealing with a discussion of the flow of metal when forged in the hot state. The author discusses the forging of metals by the pressing versus the hammering methods and summarizes his deductions into ten main divisions.

BRITISH PRACTICE IN HIGH-SPEED STEEL. By H. K. Ogilvie, Alfred Herbert, Ltd., Edgewick Works, Coventry, England, in *Iron Age,* March 8, 1923, page 679.

The above article has been taken from a paper presented at the September (1922) meeting of the Iron and Steel Institute in London, England, and gives some phases in the manufacture and heat treatment of high-speed steel. It also compares electric and crucible processes, and describes the hardening method as used by the British.

ALLOY STEEL FOR STRUCTURAL PURPOSES. In January 25, 1923 issue of *Iron Age,* page 281.

The above has been taken from a paper entitled "The Study of Steels for Engineering Structures" by Dr. Geo. K. Burgess, U. S. Bureau of Standards. It compares the use of nickel, nickel-chrome and silicon steel in constructing bridges. The possibilities of copper as an alloy is also discussed. It also states that there are possible uses of heat-treated steels in engineering structures.

DIE-SINKING UNDER A DROP-HAMMER. By Fred H. Colvin, in *American Machinist,* March 22, 1923, page 449.

The author in discussing this method states that it is one which saves time and is economical in helping to reduce the cost of die-castings.

DEFECTS IN STEEL INGOTS AND CASTINGS. By O. A. Knight, in *Forging and Heat Treating,* February, 1923, page 98.

This paper contains a comprehensive discussion of the common defects in ingots and castings including cracks, pipes, blow holes, non-metallc inclusions, coarse crystallization and segregation. The author shows by means of sketches the manner in which ingots of various shapes solidify. He likewise shows the manner in which pipes and cavities occur and how they may be materially reduced.

SCREW MACHINE PRODUCTS MADE IN LESS THAN THREE SECONDS. By Luther D. Burlingame, industrial superintendent, Brown & Sharpe Mfg. Co., Providence, R. I., in March, 1923, *Machinery,* page 507.

The author gives examples showing how rapid production can be obtained by careful tooling and machine timing.

METALS USED FOR DIE-CASTINGS. By A. G. Carman, Franklin Die-Casting Corporation, in *Machinery,* March 1923, page 516.

The above article states that the zinc-base metals and aluminum alloys as well as babbitts are the principal ones used for die-castings. There are specifications included giving the limits of weight and accuracy for die-castings made from the different metals.

(*Continued on Page* 792)

News of the Chapters

SCHEDULED REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list should communicate with the National Office in order that the list may be as complete as possible.

Boston—Second Tuesday
Bridgeport—Thursday between 20th and end of month
Chicago—Second Thursday
Cincinnati—Second Thursday
Cleveland—Fourth Friday, Cleveland Engineering Society Rooms, Hotel Winton; meeting at 8:00 p. m.
Detroit—Second and fourth Monday, Wing E., 15th Floor General Motors building.
Hartford—Friday nearest 10th of month
Indianapolis—Second Monday
Lehigh Valley—No regular night
New Haven—Third Friday
New York—Third Wednesday
Philadelphia—Last Friday
Pittsburgh—First Tuesday
Providence—No regular night. Nov. 10th, Dec. 12th.
Schenectady—Third Tuesday
Springfield—Third Friday
South Bend—Second Wednesday
St. Louis—Third Monday
Syracuse—No regular night
Tri City—Thursday
Washington—Third Friday
Rockford—Second Friday following the second Thursday

MEMBERSHIP AND ATTENDANCE CONTEST

The contest is becoming very interesting and quite rapid rearrangements are being made as some of the chapters have their machinery well oiled so that it is now in excellent working condition. It is interesting to note that four chapters have had an increase of over 50 per cent since the beginning of the contest and that for the first time Detroit is not holding position No. 1 in membership gain since Sept. 1, being 0.8 per cent below Tri City. The following arrangement of the chapters shows the percentage of net

increase of new members as of March 1 based on the number of members each chapter had on Sept. 1, 1922:

	Per Cent		Per Cent		Per Cent
1. Tri City	61.0	10. Lehigh Valley	26.8	19. Chicago	15.0
2. Detroit	60.2	11. Cincinnati	26.7	20. Washington	15.0
3. South Bend	60.0	12. Buffalo	22.5	21. Indianapolis	14.3
4. North West	52.2	13. Cleveland	20.8	22. Pittsburgh	12.2
5. Philadelphia	42.7	14. New York	20.2	23. St. Louis	10.5
6. Boston	39.4	15. New Haven	18.2	24. Springfield	10.3
7. Milwaukee	37.0	16. Toronto	17.9	25. Worcester	8.9
8. Syracuse	32.8	17. Hartford	17.8	26. Providence	0.
9. Schenectady	29.4	18. Rockford	16.7	27. Rochester	0.

Attendance at February Meetings

Only 17 chapters reported attendance at the February meeting and there are other chapter meetings, reports of which have not yet reached the office due to the fact that they were held the latter part of the month. Four chapters showed over 50 per cent of their membership in attendance, while Providence showed an attendance of 75 per cent, which is the highest percentage any chapter has shown in the contest. The following gives the percentage of attendance at the February meeting of the chapters reporting. Those printed in CAPS show an increase in percentage of attendance:

	Per Cent		Per Cent		Per Cent
1. PROVIDENCE	75.0	7. North West	39.6	13. St. Louis	25.0
2. SYRACUSE	59.0	8. PHILADELPHIA	33.6	14. Cleveland	21.6
3. TRI CITY	56.8	9. HARTFORD	33.3	15. Cincinnati	21.4
4. SOUTH BEND	51.5	10. Schenectady	31.7	16. Detroit	19.1
5. ROCKFORD	44.2	11. Indianapolis	27.3	17. Pittsburgh	14.7
6. MILWAUKEE	41.3	12. Boston	25.0		

Standing of the Chapters in Contest

In order to determine the standing of each chapter in the contest, it is necessary to add the percentage of attendance at the December, January and February meetings and divide by 3 to determine the average attendance for the three meetings. The average thus obtained is added to the percentage of net increase obtained since Sept. 1, 1922, to Feb. 28, 1923. This total is then divided by 2 to obtain the standing of each chapter in the contest inasmuch as attendance counts 50 per cent and increase in membership 50 per cent. On this basis we find the following to be the standing of the chapters on March 1 in the membership and attendance contest:

	Per Cent		Per Cent		Per Cent
1. South Bend	55.5	9. New Haven	31.0	17. Cleveland	22.0
2. Tri City	53.5	10. Rockford	30.8	18. St. Louis	21.2
3. North West	46.8	11. Toronto	30.6	19. Indianapolis	20.8
4. Detroit	41.7	12. Schenectady	30.5	20. Chicago	19.5
5. Syracuse	41.4	13. Providence	30.3	21. Washington	17.9
6. Philadelphia	37.4	14. Cincinnati	26.1	22. New York	17.5
7. Wilwaukee	33.5	15. Hartford	25.6	23. Pittsburgh	14.1
8. Boston	32.2	16. Springfield	22.3		

New Members

There were 86 new members added to the rolls during the month of February which is a very remarkable record when you consider that it was a short month. However, "there must be some bitter with the sweet"

and in this instance, the bitter is the fact that 39 members of various chapters were dropped for nonpayment of dues. These names have been listed on the monthly report to the secretary and chairman and in most instances the neglect to pay dues is an oversight. Here is an excellent opportunity for the local executive committee to give some personal attention to these members and get them to continue their membership.

In addition to the 39 members dropped from the rolls 14 resignations were received making a total loss for the month of 53 members, leaving a net gain of 33.

Based on the number of members in each chapter on March 1 the following table shows the standing of the 27 chapters of the society. Those printed in CAPS have advanced their positions, while those in *italics* have a lower position than that occupied in the report printed in March TRANSACTIONS:

1. Detroit	10. SYRACUSE	19. *Washington*
2. Chicago	11. *Lehigh Valley*	20. Buffalo
3. Pittsburgh	12. *North West*	21. Schenectady
4. Philadelphia	13. TRI CITY	22. SOUTH BEND
5. Cleveland	14. *Worcester*	23. *Springfield*
6. New York	15. St. Louis	24. *Providence*
7. Hartford	16. **Indianapolis*	25. New Haven
8. Boston	17. **Rockford*	26. Toronto
9. Milwaukee	18. CINCINNATI	27. Rochester

*Tied.

CHICAGO CHAPTER

The regular meeting of the Chicago chapter was held at the City club on Thursday evening, March 8th.

Professor H. F. Moore, of the University of Illinois gave the members a very interesting talk on: "What We Know About the Fatigue of Metals and What We Do Not Know."

This was the third meeting at which Professor Moore presented a paper before the Chicago chapter, and as evidenced by the fact that 115 members and guests were present at this meeting, the members of the Chicago chapter are exceedingly interested in the matter of fatigue failures of metals.

It is reported that Professor Moore's paper brought out one of the most interesting discussions that has ever been held before the Chicago chapter.

A special meeting of the Chicago chapter was held at the Hamilton Club on Friday evening, March 23rd, at which time Dr. Rosenhain, of the National Physical Laboratory of Teddington, England, presented a paper entitled "The Constitution of Metals and Alloys."

Dr. Rosenhain, who is an authority on the subject of metallic alloys, has been traveling and lecturing throughout the eastern and central states of the United States for the past four or five weeks and has delivered many exceedingly interesting lectures. Dr. Rosehain has a very pleasing personality and a very fine address, and the Chicago members turned out in full force to welcome their distinguished guest.

CINCINNATI CHAPTER

The Cincinnati chapter of the American Society for Steel Treating held its regular monthly meeting on March 8th, at 8:00 p.m. at the Ohio Mechanics Institute, Canal and Walnut Streets.

The program for the evening was a paper by E. W. Ehn, metallurgist with the Timken Roller Bearing Company, Canton, Ohio, who presented a paper entitled "The Relation Between Quality of Steel and Case Hardening Results."

Mr. Ehn is an authority on case hardening and carburizing and brought out many interesting facts in reference to this process.

The meeting was very well attended and proved to be a decided success.

CLEVELAND CHAPTER

On March 12th the Cleveland chapter of the American Society for Steel Treating held a joint meeting with the Ohio Section of the American Institute of Mining and Metallurgical engineers in the Ball Room of the Hotel Winton, at which time Dr. Walter Rosenhain, chief of the metallurgical department of the National Physical Testing Laboratory of Teddington, England, presented a very capable paper entitled—"The Structure and Constitution of Metallic Alloys."

Dr. Rosenhain outlined in considerable detail the methods that are employed in obtaining data for the plotting of equilibrium diagrams for various alloys. He showed many stereopticon illustrations of apparatus which he is using in his laboratory in England and which has assisted him to a large extent in arriving at the many valuable conclusions upon which he has built his numerous theories.

This meeting was attended by about 250 members and guests of the two societies and following the paper numerous questions pertaining to the subject of the paper were asked of Dr. Rosenhain.

This meeting was one of the best the Cleveland chapter has had during the present year and was preceded by a dinner served in honor of our distinguished guest.

At four o'clock on Monday, March 12th, preceding the joint meeting, Dr. Rosenhain presented a paper before the faculty of Case School of Applied Science and members and guests of the Ohio Section of the Mining and Metallurgical Engineers and the Cleveland chapter of the American Society for Steel Treating at the Case School of Applied Science, entitled "Hardness and Hardening," at which time he brought out several of his theories on the hardening of metals and metallic alloys.

On Tuesday afternoon at four o'clock, Dr. Rosenhain again presented a paper before the faculty of Case School of Applied Science and members and guests of the Ohio Section of Metallurgical Mining Engineers and the Cleveland chapter of the American Society for Steel Treating, on the subject of "Strain and Fracture in Metals," in which he developed numerous theories as to the mechanics of a progressive failure of any steel or other alloy in actual service.

All of those who had the privilege of hearing Dr. Rosenhain present

these three lectures were highly edified and certainly profited by these very capable talks.

The next regular meeting of the Cleveland chapter will be held on March 23rd, at which time the members of the National Nominating Committee of the Society will give short talks on metallurgical subjects.

In anticipation of the fact that many members of the American Society for Steel Treating will be attending the 27th annual convention of the American Foundrymen's association, the Cleveland chapter of the American Society for Steel Treating extends a cordial invitation to our visiting members and guests to attend our regular April monthly meeting held on April 27.

The meeting will be held in the rooms of the Cleveland Engineering Society, at 8 p. m. The speaker for this meeting will be Dr. P. D. Merica, metallurgist for the International Nickel Company, who will present a paper entitled "Nickel and Nickel Alloys."

DETROIT CHAPTER

The Detroit chapter of the American Society for Steel Treating held its postponed meeting on "Sheet Steel" on March 5th, 1923, at 8:00 p.m. in the east wing of the 15th floor of the General Motors building on West Grand Boulevard and Woodward Avenue.

The speaker for the meeting was H. M. Williams, research metallurgist for the General Motors Laboratories, of Dayton, Ohio, who addressed the chapter on the subject of "Automobile Sheet Steels," and illustrated his talk with a moving picture film showing the manufacture of sheets as practiced by the American Rolling Mills Co. of Middletown, Ohio.

Mr. Williams' paper brought forth a great deal of comment and discussion inasmuch as nearly all of the metallurgists and members of the Detroit chapter of the Society are interested in the use of sheets at least for automotive purposes. This subject has created considerable interest in the past and Mr. Williams' paper brought out many valuable points of information pertaining thereto.

The usual get-to-gether dinner was served at 6:00 p.m. in the cafeteria of the General Motors Company and was attended by a goodly number of members and guests.

The Detroit chapter may or may not win the contest for attendance and increase of membership but to those who attended last Monday's meeting this did not matter. As long as the chapter can draw an attendance of over 300, even with a prominent speaker, it will hold its first place among the chapters. Every automobile plant was represented. There were those who did not attend meetings for months, there were those who do not belong to the society because they think they know too much to gain anything by it; and there were those who do not belong to it because they are afraid to be in contact with fellow metallurgists, afraid of losing the mysterious prestige their own mind built around themselves. They see a fading halo around their head in the twilight, but this disappears at daylight. Well, halo or no halo, they were all there.

The Detroit chapter is a member of the Detroit Technical Societies

which is made up of a number of engineering and chemical societies. There is one joint meeting every month under the auspices of one of the member societies. The turn out is usually very fair. To our Monday's meeting the members of the affiliated societies were also invited and the attendance was the highest we have reached this year, as about 350 attended the meeting.

Of course, we had quite a drawing card. Dr. Walter Rosenhain, of London, England, one of the best known metallurgists, gave a lecture on "Strain and Fracture in Metals." It was a happily chosen subject for the mixed metallurgist, steel treater and engineering audience. It was an interesting subject to the engineers, popular with the steel treaters and a pleasant review for the metallurgists.

Dr. Rosehain's paper was very well illustrated with stereopticon slides and he brought out many valuable points in connection with the progressive failure of metals in service.

As will be recalled, Dr. Rosenhain is the author of many contributions to the science of metallurgy, both ferrous and nonferrous, and has recently delivered the honorary lecture entitled "The Nature of Solid Solutions," before the Mining and Metallurgical Engineers at their February convention in New York City.

Dr. Rosenhain is not only a very capable metallurgist, but in addition is very entertaining and pleasing in his address.

Dr. Rosenhain delivered three lectures at the University of Michigan, at Ann Arbor, and all these lectures were very well attended by the members of the Detroit chapter. (It's only too bad that our secretary didn't fill our attendance cards to our members there, it would have come very handy in our race for record attendance).

After our chapter's meeting many of us looked at members of the technical societies with eyes that twinkled and said, "See, that's us."

Detroit fellows, now let us tap each other's back. Just a little.

MILWAUKEE CHAPTER

The Milwaukee Chapter of the American Society for Steel Treating held a meeting on Friday evening, March 16th, at 8:00 p. m. in the Blatz Hotel, E. Water and Oneida Streets.

The speaker for this meeting was Dr. Enrique Touceda, consulting metallurgical engineer associated with the American Malleable Castings association, who presented a very interesting and capable paper entitled "The Manufacture of Malleable Iron."

Dr. Touceda is a very well-kown metallurgist and has done an enormous amount of very fine work with reference to malleable cast iron. It is through his efforts that the present day standards of malleable cast iron are as high as they are and that the uniformity of malleable cast iron throughout the country is as constant. This is due to the very close check-up which is continually made on the product of the various manufacturers belonging to the association.

Following Dr. Touceda's paper a very interesting discussion ensued.

Prior to the meeting a get-to-gether dinner was served in honor of Dr. Touceda, at which time a goodly number of members and guests were present.

NEW HAVEN CHAPTER

The New Haven chapter of the American Society for Steel Treating held a meeting on Friday evening, March 16th, at eight o'clock, in the assembly room of the New Haven Gas Light Company, 70 Crown Street, New Haven, Conn.

The speaker for the evening was Stanley P. Rockwell, metallurgical engineer of Hartford, Conn., who spoke on the subject of "Hardness."

Mr. Rockwell, who is the inventor of the Rockwell Hardness Tester, gave a practical demonstration in the use of his machine in obtaining the hardness of specimens. In this practical demonstration Mr. Rockwell showed the flexibility and adaptability of his machine in testing the hardness of various sizes and shapes of material both in soft and hardened conditions.

Prior to this meeting an informal get-to-gether dinner was served at the Cafe Mellone at six o'clock, at which time a good-sized turnout was had.

NEW YORK CHAPTER

The New York chapter of the American Society for Steel Treating held its regular March meeting on Wednesday, March 21, at 8:15 p. m., in the assembly room of the Merchants association of New York, ninth floor the Woolworth building.

The chapter had been especially fortunate in being able to obtain W. R. Shimer, metallurgical engineer of the Bethlehem Steel Co., Bethlehem, Pa., to present a paper entitled, "The Manufacture of Steel."

Mr. Shimer has had many years of experience in the steel business and has a vast fund of information on the subject. He delivered a very interesting and capable paper, which covered a discussion of special steels, dealing with their fatigue resisting values. Mr. Shimer illustrated his paper with stereopticon slides.

The usual get-together dinner was served at 6:00 p. m., at the Post Keller restaurant in the Woolworth building and was attended by a good sized number of guests and members of the chapter.

NORTH WEST CHAPTER

The Northwest chapter of the American Society for Steel Treating held a joint meeting with the Twin City Foundrymen's Association on March 17th, at 7:45 p.m. at the Manufacturers' Club, 200 Builders Exchange, Minneapolis, Minn.

The speaker for the meeting was Dr. Enrique Touceda, who is consulting engineer for the American Malleable Castings Association. Dr. Touceda presented a paper entitled "Malleable Iron Castings—Their Production, Properties and Uses," and brought out many valuable points of information on this subject.

Dr. Touceda is a recognized authority on the subject of malleable castings and to his efforts are largely due the present day improvements

in the quality of malleable cast iron through his diligent work with the American Malleable Castings Association.

The meeting was one of the most important that the chapter has held this year and was of particular interest to steel treaters as well as foundrymen inasmuch as the proper annealing of white iron castings is a very important operation in the production of malleable castings.

In honor of Dr. Touceda a dinner was served at 6:30 p.m. which was well attended by members of both societies.

PHILADELPHIA CHAPTER

The Philadelphia chapter of the American Society for Steel Treating held its regular monthly meeting on Friday evening, March 23, at 8:00 p. m., in the Engineers' Club rooms, 1317 Spruce street, Philadelphia.

The program for this meeting was a paper by Dr. P. D. Merica, director of research at the International Nickel Co., who presented a paper entitled, "Metallurgy and Heat Treatment of Nickel and Its Alloys."

In this talk Dr. Merica traced the history and development of the metallurgy of nickel and described in detail the several principal methods used for the refining of nickel.

As nickel has many uses in the industry, the principal one of which is its use in the production of nickel steel, there being over 50 per cent of the total nickel production of the world going into the manufacture of nickel steel, it was pointed out that the two principal uses of nickel steel are for armour plate and automotive parts.

In his paper Dr. Merica gave a series of curves and data indicating the value and the usage of nickel in steel. It was also shown that merit index of nickel steel was considerably higher than that of the carbon steel of equal carbon content and compared favorably with other alloy steels.

Of the many other uses of nickel the following may be named as principal:

Its use combined with a percentage of copper in coinage.

Its extensive use in the alloy known as "German silver," which is a nickel-copper-zinc alloy and cupro-nickel.

It was stated that about 5 per cent of the total nickel production is used for nickel-plating work.

Following Dr. Merica's paper, A. H. Kingsbury, metallurgical engineer, Atha Works of the Crucible Steel Co., gave a practical talk entitled, "Tool Room Troubles." As Mr. Kingsbury has had charge of the high-speed steel production for the Crucible Steel Co. for many years he has had many years of practical experience in heat treating and developed a very interesting talk as evidenced by the large amount of discussion which followed his paper.

The usual get-together dinner was served at 6:30 p. m., in the club dining room and it was attended by a large number of members and guests.

The meeting itself was attended by a large number of members and guests and proved to be one of the most interesting meetings that the Philadelphia chapter has had this year.

PITTSBURGH CHAPTER

Professor F. F. McIntosh, associate professor of metallurgy, Carnegie Institute of Technology, gave a very interesting talk on "The Application of

Fatigue Testing of Metals to Industrial Problems," before the Pittsburgh chapter of the American Society for Steel Treating at their regular monthly meeting on March 8, 1923, at the William Penn hotel.

Professor McIntosh presented some very valuable and interesting information regarding fatigue-resisting values of upset seamless drill tube of low and high-carbon composition, and their comparison in the raw worked and the annealed structural condition. His research work established the fact that the life of a 0.50 per cent carbon tube material, after upsetting for enlargement of section for threading, is very short and invariably fails at the zone which becomes granular and strained because of the partial heating of the ends of the tube.

The use of low-carbon steel, which has been thought necessary to avoid dangerous embrittling, was found to offer very little insurance against these failures. A short-time anneal, however, gave an endurance limit of satisfactory value and equal to that of the original material. An increase in carbon content from 0.15 per cent to 0.50 per cent, in conjunction with an anneal after upsetting, gave test values which were very much in excess of any results ever before obtained. These results were substantiated by service records presented. A very animated discussion ensued in which practically the entire assembly participated.

The meeting was probably the most interesting one of the season and was well attended.

ROCKFORD CHAPTER

The Rockford chapter of the American Society for Steel Treating held its regular monthly meeting on Friday, March 16, at 7:00 p. m., at the Nelson hotel, at which time the usual get-together dinner was served to a goodly number of members.

The program for this meeting consisted of reports by the members who attended the winter sectional meeting in Chicago and were followed by round table talks on various metallurgical subjects.

This meeting was well attended and many valuable thoughts and ideas were brought out which proved to be of value and benefit to the members.

SCHENECTADY CHAPTER

The regular February meeting of the Schenectady chapter was held on February 26th at the American Locomotive Works, Schenectady.

The speaker for the evening was L. S. Fuller, of the General Electric Research Laboratory, who addressed the chapter on the subject of "Hydrogen: The Dr. Jekyl and Mr. Hyde of Metallurgy," pointing out the dangers resulting from the action of pickling and plating baths on steel, and especially on hardened steel, due to the liberation of nascent hydrogen. Mr. Fuller also brought out points on the many useful applications of hydrogen with no attendant dangers.

This meeting was very well attended and the speaker's paper brought forth much valuable and interesting discussion.

SPRINGFIELD CHAPTER

The Springfield chapter of the American Society for Steel Treating held a meeting on Thursday evening, March 1st, at the Technical High School hall, Elliot Street.

The program for the evening was a paper by J. V. Emmons, metallurgist of the Cleveland Twist Drill Company, and treasurer of the National Society, who presented an interesting paper on the "Machinability of Tool Steel."

Mr. Emmons' paper was very capably presented and brought forth a large amount of interesting and valuable discussion.

In addition to Mr. Emmons' paper a series of moving pictures were exhibited entitled "The Uses and Abuses of Twist Drills." This film is the property of the Cleveland Twist Drill Company and outlines a six weeks' course in Drilling. The film shows how to grind a drill to eliminate as far as possible breakage during drilling and shows how production can be increased by sharpening a drill in the proper manner. It also shows many instances of high speed drilling and some of the examples shown were record time for the drilling of the slab in question.

This meeting was very well attended and proved to be a decided success.

SOUTH BEND CHAPTER

The South Bend chapter of the American Society for Steel Treating held its March monthly meeting on the 14th at the No. 2 Plant of the Studebaker Corporation.

In accordance with the policy of having a member of the chapter read a paper at each meeting of the chapter, Leo Jordan, read a paper entitled: "Temperature Measurements by Pyrometers and Maintenance of Instruments Used."

Mr. Jordan illustrated his paper by the use of lantern slides and brought out some exceedingly interesting information with reference to the subject of pyrometry. This paper brought forth some interesting and valuable discussion.

The main speaker of the evening was E. J. Janitzky, metallurgical engineer of the Illinois Steel Company, South Chicago, Illinois.

The subject of Mr. Janitzky's paper was "Melting Processes Employed In The Manufacture Of Steel." This paper was indeed very instructive and described in detail steel mill practices including the open-hearth, Bessemer, and electric furnace methods of producing steel.

Following Mr. Janitzky's talk two reels of moving pictures taken at the plant of the Illinois Steel Company, South Works, were exhibited, and Mr. Janitzky answered questions with reference to them after they had been exhibited. The meeting was very well attended, there being 78 members and guests present.

At the April meeting of the chapter, Professor H. M. Boylston, of Case School of Applied Science will be the speaker, and a joint meeting will be held with the American Chemical Society.

SYRACUSE CHAPTER

The Syracuse chapter of the American Society for Steel Treating held its regular monthly meeting on March 15, at the Yates hotel, at which time S. C. Spalding, of the Halcomb Steel Co., Syracuse, presented an interesting paper entitled, "Carburizing."

Mr. Spalding has done a great deal of very valuable work along carburizing lines and has presented several very interesting papers, notable among which is his paper which appeared in the August, 1922, issue of TRANSACTIONS.

Following Mr. Spalding's presentation, a large amount of interesting and valuable discussion was brought out.

The usual get-together dinner was served at 6:00 p. m., and was attended by a goodly number of members and guests.

An attendance of about 50 members and guests was the score for the meeting proper. The meeting proved to be highly successful and without doubt many of the members and guests obtained much valuable information from Mr. Spalding's very capable presentation.

TRI-CITY CHAPTER

The Tri-City chapter of the American Society for Steel Treating held its regular monthly meeting March 15, at the Davenport Chamber of Commerce.

This meeting was a joint meeting of the Tri-City chapter and the Quad-City Foundrymen's association. The meeting was called to order at 8 p. m. by the chairman, who announced the results of the "Membership and Attendance Contest" as of Feb. 28, showing that the Tri-City chapter was in second place and had secured the largest increase in membership.

A nominating committee for the officers for the ensuing year was appointed by the chairman. The committee is composed as follows:

Harold Brown, chairman,
A. H. Putnam,
C. H. Lage.

The meeting was then turned over to the Quad-City Foundrymen's association and they held a short business session. Then the meeting was turned back to the chairman of the Tri-City chapter and he introduced the speaker of the evening, Dr. Enrique Touceda, of Albany, N. Y., consulting engineer of the American Malleable Castings association. Dr. Touceda spoke on the subject of "Malleable Cast Iron." Dr. Touceda traced the historical development of iron making, and showed how the blast furnace was first evolved. He discussed the methods of grading pig iron and showed that the grading by fracture did not give the correct results.

In order to secure a white iron which will give malleable castings with the desired physical properties, it is necessary to have the white iron of a fairly definite chemical composition. Otherwise, considerable difficulty may be experienced in the annealing of these castings. Consequently, it is essential to have very close chemical control in the successful operation of a malleable iron foundry. Dr. Touceda showed pictures of melting furnaces and annealing furnaces and told why the

air furnace was generally used for the production of the white iron. His talk was illustrated with a large number of lantern slides. A considerable number of photographs of the structures of various irons were shown and discussed. The results of improper composition and of improper annealing practice were clearly shown by these photographs.

Dr. Touceda stated that approximately 1,200,000 tons of malleable castings were produced annually and that the major portion of this production was used in the automotive industry. A rising vote of thanks was tendered to Dr. Touceda for his kindness in coming to the Tri-Cities and addressing the joint meeting. The meeting adjourned at 10:30 p. m. Attendance at the get-together dinner, 103. Attendance at the meeting, 115.

WASHINGTON CHAPTER

The February meeting of the Washington chapter was held Tuesday evening, February 27th, at 8:00 p.m. in the auditorium of the new Interior Department building, corner of Eighteenth & "F" Streets, Northwest.

The program for this meeting was a paper by J. V. Emmons, metallurgist of the Cleveland Twist Drill Company, and treasurer of the National Society, entitled "Machinability of Tool Steel."

Mr. Emmons discussed various phases of his work in studying the relationship between machinability of steels for use in the manufacture of tools and the methods of obtaining the desired results by the proper control of annealing and heat treating processes.

The presentation of Mr. Emmons' paper required about forty-five minutes and was followed by a one hour and thirty minute discussion which brought forth many valuable and interesting features.

In addition to Mr. Emmons' paper, J. J. Crowe, metallurgist with the Philadelphia Navy Yard, and a director of the national society, gave a short talk on a metallurgical subject.

Mr. Laury, metallurgist with the Bethlehem Steel Company, Bethlehem, Pa., presented a short talk on some of the plans for the sectional meeting which will be held in Bethlehem in June of this year.

The February meeting of the Washington chapter was unusually successful and will undoubtedly raise the chapter's standing in the attendance and membership list.

On Friday evening, March 16, 1923, the Washington chapter of the American Society for Steel Treating held a meeting in the auditorium of the new interior department building, at the corner of Eighteenth and F streets, at which time, Jerome Strauss, chief chemist, United States naval gun factory, Washington, D. C., presented a very capable paper entitled, "Performance of High-Speed Cutting Tools."

Mr. Strauss pointed out that modern mechanicalized production has reached its present stage of development through the co-ordination of many factors, prominent among which is the application of high-speed steel tools. It was indicated that information and data pertaining to the variations in properties and performance of high-speed tools as effected by composition,

manufacturing methods, heat treatment and operating conditions are not as well known as they should be, although a great deal of research has been done along those lines.

Mr. Strauss brought out many of these factors. Following his paper a very interesting discussion was held.

WORCESTER CHAPTER

The regular monthly meeting of the Worcester Chapter of the American Society for Steel Treating was held Tuesday evening, March 22nd, at 8:15 p. m., at the Worcester Polytechnic Institute, in the Electrical lecture-room, Salisbury Street, Worcester, Mass.

The program for this meeting was a feature motion picture entitled "The Story of Steel," which has recently been produced by the U. S. Bureau of Mines.

This picture proved to be exceedingly interesting, tracing the manufacture of steel from the ore beds to the finished product. The story of the film was very interestingly told by a competent lecturer.

The meeting was exceptionally well attended and proved to be interesting to all.

ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A repesents Associate Member; S represents Sustaining Member; J represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

NEW MEMBERS

ALLEN, H. B., (M-12), c/o Henry Disston & Sons Co., Inc., Philadelphia, Pa.
AMMONS, CLEMENT, (M-2), 410 Seeberger Street, South Bend, Ind.
ANDERSON, JOHN W., (M-3), c/o Maxwell Motor Corp., New Castle, Ind.
ANDERSON, THEODORE G., (M-2), 2831 No. Maplewood Avenue, Chicago, Ill.
ATWATER, R. M., (A-2), 1108 Majestic Bldg., Detroit, Mich.
BEAM, DANIEL A., (M-3), c/o The John Illingworth Steel Co., Frankford, Philadelphia, Pa.
BETTENDORF CO., (S-3), Bettendorf, Iowa.
BRICKNER, H. A., (Jr.-2), c/o American Chain Co., Inc., York, Pa.
DeMOSS, IRA M., (M-3), Haney Avenue, South Bend, Ind.
DONAHUE, D. A., (M-3), 1706 E. Ewing Avenue, South Bend, Ind.
DORSEY, C. B. Jr., (M-1), 523 South Main Street, Geneva, N. Y.
DOWNS, BERNARD I., (Jr.-3), Stafford Avenue, Forestville, Conn.
CLARK, HOMER A., (M-2), 1674 Pingree Avenue, Detroit, Mich.
COLEMAN, WM. B., (M-3), 588 Drexel Bldg., Philadelphia, Pa.
COLONIAL STEEL CO., (S-3), c/o Mr. James Dunlevy, 145 Water Street, New Haven, Conn.
CREUSERE, GORDON C., (A-3), 49 North Avenue, Highland Park, Mich.
CRANS, W. B., (M-1), 1503 St. Clair Avenue, Detroit, Mich.
CROSEY, W. H., (M-2), c/o Pollak Steel Co., Cincinnati, O.
CROSS, HOWARD C., (Jr.-2), 1222 Eighth Street, Washington, D. C.
ESCH, EDWARD, (M-2), 628 North Scott Street, South Bend, Ind.
FINANCE OFFICE, CHEMICAL WARFARE SERVICE, (Sub.-1), Edgewood Arsenal, Edgewood, Md.
FISHER, EDWIN J. P., (M-3), 48 South Main Street, Wallingford, Conn.
FOSNIGHT, P. F., (A-2), 222 W. Larned Street, Detroit, Mich.
FRASER, WILLIS P., (M-2), c/o New Departure Mfg. Co., Bristol, Conn.
FRENCH & HECHT, (S-3), Davenport, Iowa.
GEOMETRIC TOOL CO., THE (S-3), New Haven, Conn.
GIFFORD, HARRY L., (M-2), Box 215, Midland, Pa.
GREEMAN, O. W., (M-12), 24 Hendricks Place, Indianapolis, Ind.
GREEN, HARRY J., (M-3), 1940 West Vermont Street, Indianapolis, Ind.
GRIFFITHS, JOHN W., (M-3), Bethlehem Steel Co., Bethlehem, Pa.
GRIGGS, E. R., (M-10), Lufkin Rule Co., Saginaw, Mich.
GRILL, C. H., (M-2), 5479 Harper Avenue, Chicago, Ill.
HAHNEFELD, CHAS., (M-3), Studebaker Corp., South Bend, Ind.
HARTFORD ELECTRIC LIGHT CO., (S-2), Hartford, Conn.
HAYES, FULLWOOD P., (Jr.-3), 218 West Ruscomb Street, Philadelphia, Pa.
HIBERT, CHAS., (M-3), 723 Washington Street, Oakmont, Pa.
HOPP, WILLARD C., (M-2), Studebaker Corp., South Bend, Ind.
HULL, W. H., (M-3), 622 Eighteenth Street, Moline, Ill.
JOHNSON, CHAS., (M-2), 2011 South Clyde Street, South Bend, Ind.
JOHNSON, JOHN, (M-1), c/o Miehle Printing Press & Mfg. Co., Chicago, Ill.
JOHNSON, VICTOR, (M-1), 319 Herkimer Street, Syracuse, N. Y.
JOHNSTON, JAMES G., (M-3), c/o Dort Motor Car Co., Flint, Mich.
JORDAN, RICHARD C., (A-3), 2923 Wasp Road, Fairview, Camden, N. J.
KAVANAUGH, M. R., (M-3), Studebaker Corp., South Bend, Ind.
KROPF, FRED (M-2), 159 Kinsey Avenue, Mt. Auburn, Cincinnati, O.
LINCOLN, H. W., (M-3), c/o Conn. Light & Power Co., Waterbury, Conn.
LOOP, J. F., (M-3), Y. M. C. A., Moline, Ill.
LORENZ, HERBERT, (M-2), 364 Eastlawn Avenue, Detroit, Mich.
LUCKETT, D. J., (M-3), 712 East Fourteenth Street, Davenport, Iowa.
MILLARD, JAS. M., (A-3), P. O. Box 693, Providence, R. I.
MOELLER, ERNEST E., (M-4), 3218 McKinley Boulevard, Milwaukee, Wis.
MONTGOMERY, HARLEY A., (S-2), c/o Wayne Soap Co., Copeland & M. C. R. R., Detroit, Mich.

MORRIS, WHEELER & CO., (S-3), Thirtieth & Locust Streets, Philadelphia, Pa.
NEMETZ, JULIUS, (M-2), 915 Second Avenue, Rockford, Ill.
NEUNER, C. L., (M-2), c/o Interstate Iron & Steel Co., E. Chicago, Ind.
OATMAN, RALPH B., (M-3), 6908 Harper Avenue, Chicago, Ill.
PARRISH, J. G., (M-3), The Linograph Co., Davenport, Iowa.
PAQUE, E. J., (M-2), 980 Fairbanks Avenue, Cincinnati, Ohio.
PESKOWITZ, S., (M-1), 840 Sumner Avenue, Syracuse, N. Y.
PETERSON, N. P., (M-3), 278 DeCorcelle Street, Montreal, Quebec, Canada.
PURINTON, FOREST G., (M-2), c/o Patent Button Co., P. O. Box 1028, Waterbury, Conn.
RITZLOFF, OTTO, (M-1), Worthington Pump & Machine Corp., Cudahy, Wis.
STRAND, C. H., (M-3), 2955 East Ninety-second Street, Cleveland, O.
TROXWELL, G. B., (M-3), 185 Charles Street, Easton, Pa.
VANNIER, EDGAR, (M-3), The Linograph Co., Davenport, Iowa.
VOSS, H. W., (M-2), 1765 Olive Avenue, Chicago, Ill.
WAARICH, OTTO C., (M-3), c/o Pheoll Mfg. Co., 5700 Roosevelt Road, Chicago, Ill.
WAECHTER, J. EDMUND, (M-3), c/o Brown-Sharpe Mfg. Co., Providence, R. I.
WAKELAM, JAMES P., (M-3), Y. M. C. A., Moline, Ill.
WEAVER, WM. G., (M-10), Department of Mechanical Engineering, University of Cape Town, Cape Town, South Africa.
WELKER, E. H., (A-1), 222 West Larned Street, Detroit, Mich.
WENZINGER, CARL J., (Jr.-2), Swarthmore College, Swarthmore, Pa.
WIDEMAR, C. H., (Jr.-3), 7312 Frankford Avenue, Holmesburg, Pa.
WINDFELDER, CLIFTON, (A-3), 858 Forty-seventh Street, Milwaukee, Wis.
YALE & TOWNE MFG. CO., (Sub.-1), Works Library, Stanford, Conn.

CHANGES OF ADDRESS

ABEGG, W. A., from 653 North Main Street, to 2533 East Twenty-sixth Street, Los Angeles, Cal.
ATKINS, G. F., from 109 East St. Clair Street, to E. C. Atkins & Co., Indianapolis, Ind.
BUTT, HOWARD, from 1156 Leader-News Bldg., Cleveland, to 9 Neponset Street, Worcester, Mass.
CHAMBERLAIN, G. D., from Box 431, to American Chain Co., Bridgeport, Conn.
COWELL, W. T., from 4239 Hamilton Avenue, to 1851 Chase Avenue, Cincinnati, O.
DAVIS, F. G., from 2444 West Grand Boulevard, Detroit, to Iroquois Steel Co., Buffalo, N. Y.
DIEDERICHS, WM. J., from 1027 Lincoln Way, to 915 Duff Avenue, Ames, Iowa.
DREW, E. G., from Y. M. C. A., Moline, Ill., to 273 West Third Street, Mansfield, O.
DREXLER, CHAS., from Stevenson Gear Co., to 311 East South Street, Indianapolis, Ind.
FROST, M. A., from 1005 Alexander Street, to 700 Chestnut Street, Latrobe, Pa.
HARRIS, F. E., from 205 West Anne Street, to 230 Grace Street, Flint, Mich.
HARRIS, H. H., from 122 South Michigan Avenue, Chicago, to 405 West First Street, Boston, Mass.
HEATH, LESLIE J., from Simonds Mfg. Co., Fitchburg, to 33 Logan Avenue, Medford, Mass.
JAYME, W. A., from 19 Pomander Walk, West Ninety-fifth Street, New York City, to 1120 Piedmont Avenue, Canton, O.
KIRKPATRICK, T. L., from Wheelock, Lovejoy Co., Cambridge, Mass., to A. E. Hunt Steel Co., Boston, Mass.
KLOPSCH, O. Z., from 3250 Highland Place, to 1813 Columbia Road, Washington, D. C.
KUTAR, P., from 4617 Center Avenue, to 258 Oakland Avenue, Pittsburgh, Pa.
LAGE, C. H., from Linograph Co., Davenport, Iowa, to Yellow Sleeve Valve Engine Co., East Moline, Ill.
LOVE, W. D., from 1437 Franklin Street, Detroit, to Latrobe Steel Co., New York City.
NEWCOMB, E. S., from 14017 Baldwin, to 1740 East Twelfth Street, Cleveland, O.
NIXON, H. K., from 326 Hendrie Street, Detroit, to 424 Pleasant Street, Royal Oak, Mich.
PENNEY, R. L., from 34 West Rock Avenue, New Haven, to 21 Lincoln Street, New Haven, Conn.
REINHOLD, B., from 653 North Main Avenue, to 2533 East Twenty-sixth Street, Los Angeles, Cal.

SADTLER, C. B., from 1615 North Meade Avenue, to Western Electric Co., Chicago, Ill.
SHERMAN, P. B. Jr., from Y. M. C. A., Canton, O., to 147 Exeter Terrace, Buffalo, N. Y.
STEPAN, A. C., from 589 East Illinois Street, to 230 East Ohio Street, Chicago, Ill.
SYKES, LEWIS, from 1412 Baird Avenue, to New York Shipbuilding Corp., Camden, N. J.
WATSON, J. M., from Hupp Motor Car Corp., to 226 Eason Avenue, Highland Park, Mich.
WILLETS, C. L., from 117 Dearborn Place, to 1040 West Colvin Street, Syracuse, N. Y.
WILLS, WM. H., from 437 South Avenue, Wilkinsburg, Pa., to 307 Roosevelt Avenue, Dunkirk, N. Y.
ZETZER, HENRY, from 2872 East 112th Street, to 3630 Shaker Road, Cleveland, O.

MAIL RETURNED

C. F. BOYD, Nordyke & Marmon Co., Indianapolis, Ind.
T. B. FUNK, Midwest Engineering Co., Indianapolis, Ind.
C. P. MORRELL, 511 Bulkley Bldg., Cleveland, O.
C. F. TEUBER, Peoples Gas Light & Coke Co., 325 South Michigan Avenue, Chicago, Ill.

Abstracts of Technical Articles

(*Continued from Page* 776)

SOFTENING GRAY IRON BY ANNEALING. By Dr. I. E. Piwowarsky, in *Forging and Heat Treating,* February, 1923, page 127.

This article is a translation from Stahl und Eisen and deals with the object and theory of the annealing of cast iron.

ADVANTAGES OF BUILT-UP DIE CONSTRUCTION. By C. E. Stevens, chief engineer, White Sewing Machine Co., Cleveland, Ohio, in *Machinery,* for March, 1923, page 528.

The author states that built-up dies are those in which the surfaces that are subjected to wear and that are difficult to machine are made in two or more parts and properly assembled. He also describes the advantages of this construction.

THE HEAT TREATMENT OF ALLOY STEELS. By R. R. Moore and E. V. Schaal, in *Forging and Heat Treating,* February, 1923, page 113.

The authors discuss the effect of heat treatment upon the metallographic and physical characteristics of chrome-nickel, chrome-vanadium, and chrome-molybdenum steels.

HEAT TREATMENT OF ELECTRIC CARBON AND ALLOY FORGING STEELS. By L. J. Barton, in *Forging and Heat Treating,* February, 1923, page 102.

The effect of heat treatment on the physical properties of plain carbon and alloy steels containing nickel, chromium, molybdenum and vanadium are discussed.

EMPLOYMENT SERVICE BUREAU

The employment service bureau is for all members of the Society. If you wish a position, your want ad will be printed at a charge of 50c each insertion in two issues of the Transactions.

This service is also for employers, whether you are members of the Society or not. If you will notify this department of the position you have open, your ad will be published at 50c per insertion in two issues of the Transactions. Fee must accompany copy.

Important Notice.

In addressing answers to advertisements on these pages, a stamped envelope containing your letter should be sent to AMERICAN SOCIETY FOR STEEL TREATING, 4600 Prospect Ave., Cleveland, O. It will be forwarded to the proper destination. It is necessary that letters should contain stamps for forwarding.

POSITIONS WANTED

WANTED—POSITION AS SUPERVISOR of a heat treating department. Have had 12 years experience in heat treating, tool and die hardening. Address 4-5.

WANTED—POSITION AS HARDENER. Have had 5 years practical experience with a large firm in general hardening of both carbon and high-speed steel as well as carburizing. Fully competent. Age 35. Married. Address 4-10.

METALLURGIST WITH 8 YEARS EXPERIENCE in the analysis of ferrous and nonferrous metals, physical testing, metallography and heat treatment of plain and alloy steels, desires responsible position in laboratory of well established concern. Address 4-15.

POSITION IS DESIRED AS FOREMAN OF HEAT TREATING DEPARTMENT. Seven years of high grade experience with carbon, high speed, and alloy steels, covering all phases of heat treating. Best references. Address 4-20.

POSITION WANTED IN METALLURGICAL LABORATORY. Seven years of high grade experience in metallographic testing, research work and experimental heat treating; also pyrometry technical training. Best eferences. Address 4-25.

EXPERIENCED TOOL HARDENER would like a position in or around New York. Has had 11 years experience. Can harden and carburize all kinds of steel. Can give first class references if desired. Address 4-30.

AS WORKS SUPERINTENDENT with 16 years of high grade experience in all branches of tool and metal parts manufacturing. Can assure maximum quality production at a minimum cost. Best of references. Address 4-35.

CHEMIST and HEAT TREATER. Technical graduate. Experience in chemical, physical testing and heat treating of steels. Eastern location preferred. Reasonable salary. Address 2-1.

METALLURGIST—Desires Position—Nine years experience both in research and production in tool steel mills, standardization heat treatment of tool steels, metallography ferrous and non-ferrous metals, pyrometry, physical and chemical testing. Address 2-15.

POSITIONS OPEN

DIE BLOCK DESIGNER and hardener wanted by an eastern concern who manufacture die blocks. This position offers an excellent opportunity for one who has had experience in both the designing and hardening of blocks. State experience and qualifications. Address 4 40.

GRADUATE METALLURGIST—Recent metallurgical graduate wanted for metallurgical department of a tool steel mill. Opportunity for experience and advancement. Western Pennsylvania. State in reply, education, age and experience, if any. Give three references. Address 3-10.

TOOL STEEL SALESMAN. New England States. Prefer one acquainted with the trade and now handling similar line. Do not apply unless you have had experience. This is one of the largest tool steel companies in the country, and affords a splendid opportunity for the right man. Address 3-5.

TECHNICAL GRADUATE with 2 years (or possibly less) experience. Preferably graduate in mechanical engineering with testing materials experience or training. Man would have variety of work such as mixing alloys, testing of materials and helping with miscellaneous experiments. Approximate salary $150 per month. Location Cleveland. Address 2-25.

TECHNICAL GRADUATE to assist in experimental work in metallographic laboratory preferably with training in physical measurements. Metallurgical training or experience desirable but not absolutely necessary. Approximate salary $150.00 per month. Location Cleveland. Address 2-20.

FOREMAN to take charge of hardening department in plant in east. Must be able to harden tools, such as broaches and reamers and carbon and high-speed steel as well as case hardening. Address 12-1.

FOR SALE

FOR SALE—Two Wilson-Maeulen Tapalog Recorders, 4 point, 75-1800°F. Scale. Condition perfect, practically new. Can be purchased for less than one-half factory price. For further information write Box No. 2-5 A. S. S. T.

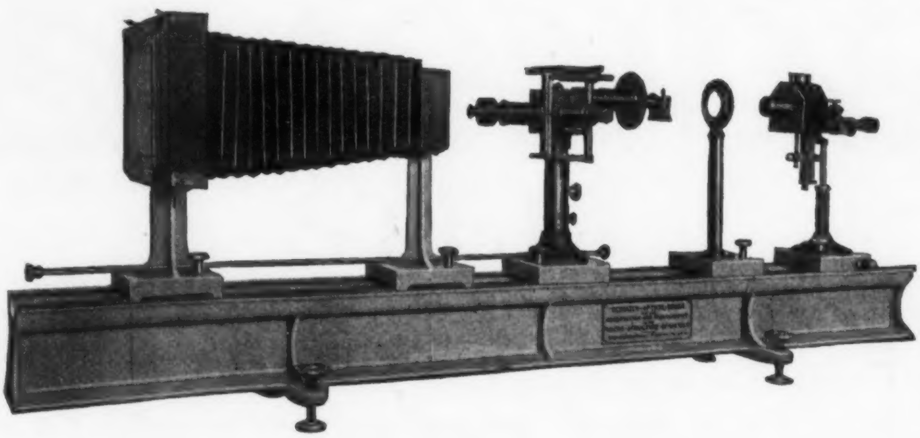
Items of Interest

The Bristol Company, Waterbury, Connecticut have recently published a catalog, No. 1006, on Bristol's Recording Gauges for Pressure and Vacuum. As a result of more than thirty years' experience in designing and manufacturing recording instruments, this company now offers one of the most complete line of recording pressure and vacuum gauges that has ever been placed on the market. More than seventy-five thousand of these instruments have been sold.

The Atlas Steel Corp. has recently taken new district sales offices in the Hanna Building, Cleveland, Ohio. W. H. White, who was formerly president of the B. M. Jones & Co., Inc., importers of Mushet steels and Taylor iron, has been appointed manager. With the direct representation from the mill and the distributors as now appointed, the Atlas Steel Corp., is in a position to give exceptionally good service. The distributors are: The W. Bingham Co., Cleveland; Dickerson Steel Co., Dayton, O.; and Mitchell Steel Co., Cincinnati.

The United States Bureau of Mines lists the following as the most important factors affecting the contraction of a non-ferrous alloy on casting: (1) Chemical composition of the alloy; (2) pouring temperature; (3) cross-section of the bar poured; (4) length of the bar in relation to its cross-section; (5) character of the mold, and the method of molding; (6) gas occlusion, and overheating of the melt. These factors are discussed briefly in Serial 2410, "Contraction and Shrinkage of Non-Ferrous Alloys as Related to Casting Practice," which may be obtained from the Bureau of Mines, Washington, D. C.

The Bausch & Lomb Optical Co., Rochester, N. Y., has published a 20-page illustrated booklet in which a device for measuring contours of mechanical parts by optical projection of a magnified image is described and illustrated. The device was developed for use in the company's own plant. According to the booklet it is adapted for use by all manufacturers of gages, all kinds of threaded work and a great variety of formed work such as gears or form cutters. Its application in the inspection of the contour of all sorts of small parts, covering the checking of the gage, the checking



SCIMATCO OPTICAL BENCH

For the Examination and Photography of the Micro-Structure of Metals

Magnifications 28 to 3100 diameters

The advanced equipment adopted by many of the leaders in Metallography.

Substantial, no vibrations, stage will support large and heavy pieces, may be fitted with Macro-Attachment so that large fields may be examined and photographed.

(*Write for Booklet*)

SCIENTIFIC MATERIALS COMPANY
"Everything for the Laboratory"
PITTSBURGH, PA.

of the work, and after heat treating, the detection of distortion, is unlimited. The device is described and illustrated in detail.

The Cutler Steel Co., Pittsburgh, plant of which is at New Cumberland, W. Va., is in production on its chromium iron alloy, known in the trade as "Duraloy."

The Crompton & Knowles Loom Works, Worcester, has completed plans for enlarging its forge shop and heat-treating department by an addition, 80 x 100 feet, of brick and steel, one story, with monitor roof. The present forge shop has been outgrown, and increased equipment and general facilities are required.

Richard Rimbach, who was formerly metallurgist in charge of research laboratory for the Standard Steel Car Co., Butler, Pa., has become affiliated with the Jones & Laughlin Steel Co., Pittsburgh.

The Twenty-seventh Annual Convention of the American Foundrymen's Association will convene in Cleveland, Ohio, Monday, April 30th, continuing through Thursday, May 3rd. Registration, Headquarters, and Exhibits will all be located in the Cleveland Auditorium on Sixth Street.

All technical meetings of the American Foundrymen's Association and the Metals Division will be held at The Hollenden Hotel, Sixth and Superior Streets, two blocks from the Auditorium.

C. E. Hoyt, secretary, calls attention to the fact that the Exhibits will open on Saturday, April 28, remaining open until 10:00 p. m. Saturday evening, will be closed on Sunday, and open from 9:00 a. m. until 5:00 p. m., Monday, Tuesday, Wednesday and Thursday. Saturday will be known as Cleveland Day for inspection of Exhibits.

Attractive entertainment will be provided for members and ladies in attendance. On Tuesday evening, May 1st, foundrymen's get-together and good fellowship meeting will be staged. High class entertainment is assured and every foundryman present at the convention will want to attend. On Wednesday evening, May 2nd, the annual subscription banquet will be held. The banquet committee promises speakers of national reputation. This is an event which foundrymen should not miss and to which the ladies are invited.

A very comprehensive and interesting technical papers' program has

been arranged, dealing with nonferrous as well as ferrous metallurgy and foundry practice. This convention undoubtedly will be the largest that the association has ever held.

L. K. Berry, for sixteen years with the Warner & Swasey Co., Cleveland, Ohio, has resigned his position of domestic sales manager to become manager of sales for the Detroit Twist Drill Co., Detroit, Mich.

Automatic & Electric Furnaces Ltd., Elecfurn Works, London, have issued a pamphlet showing the sizes of Wild-Barfield Furnaces which they manufacture and their application in the hardening room.

Horace T. Potts, for 56 years head of Horace T. Potts & Co., Philadelphia, iron and steel merchants and importers, died recently.

Brace, Mueller & Huntley, Inc., with offices in Buffalo and Syracuse, have been appointed distributing agents in New York state west of Schenectady, for the Atlas Steel Corp., Dunkirk, N. Y.

J. S. Marlowe has been appointed district sales manager in the Indianapolis district for the Atlas Steel Corp., Dunkirk, N. Y. Mr. Marlowe has opened offices at 914 Roosevelt building, Indianapolis.

The Chrobaltic Tool Company, Chicago, have announced that they are in a position to supply to users of heat-resisting materials a general line of "Fire-Armor" products for all heat treating purposes. They have a well equipped foundry located at Michigan City, Indiana, which has good shipping facilities. They are also equipped to machine special castings of all kinds, and to manufacture alloy sheet containers, dipping baskets, and similar fabricated articles.

The New York Testing laboratories, New York City, has installed a new automatic 100,000 lb. Tinius Olsen testing machine for handling of tensile tests, compression tests, transverse tests, etc.

The Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin have issued Bulletin 141 which is entitled "Research in Materials." The booklet gives the investigations of "Comparative Tests of Steels at High Temperatures" and "Annealing of Gray Cast Iron." It is fully illustrated.

Lucien I. Yeomans, industrial engineer, Chicago, has been appointed chief engineer of the A. O. Smith Corporation, Milwaukee.

pril

and
the

ve-
me

ave
ey

la-

se,
ec-

n-
we

re
ne
ell
ng
ls,
ar

w
le

in
ne
gh
d.

ed